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 Three Hatchery and Genetic Management Plans for Dungeness River Basin Salmon under Limit 6 of the Endangered Species Act Section 4(d) Rule (Reinitiation 2019)

NMFS Consultation Number: WCRO-2018-01254

Action Agencies: National Marine Fisheries Service (NMFS)
Bureau of Indian Affairs

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?
Puget Sound steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	No
Puget Sound Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No

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

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

Issued By:

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Date: **September 24, 2019**

TABLE OF CONTENTS

Table of Tables

Table of Figures

1. INTRODUCTION

On June 10, 2016, the National Marine Fisheries Service (NMFS) made a determination that the Dungeness River Basin Chinook salmon, coho salmon, and pink salmon hatchery programs satisfy the requirements under Limit 6 of the Endangered Species Act (ESA) Section 4(d) Rule. To reach the determination, NMFS completed a biological opinion (2016 BiOp) that evaluated the effects of its determination that the Dungeness River Basin Chinook salmon, coho salmon, and pink salmon 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.

NMFS is now proposing to make a new determination under Limit 6 of the 4(d) Rule for these Dungeness River Basin hatchery program as a result of an increase in the size of the coho hatchery program previously determined to meet Limit 6. In this reinitiated biological opinion, the National Marine Fisheries Service (NMFS) evaluates whether the newly submitted HGMP for the Dungeness River coho program, in conjunction with the HGMPs for the Chinook salmon and pink salmon programs previously analyzed, meets the requirements of Section 4(d) Limit 6. The 2016 BiOp (NWR-2013-9701), which analyzes its prior determination regarding the HGMPs, is superseded by this biological opinion, although this opinion incorporates by reference elements of the 2016 BiOp that still remain valid. For ease of reference, the 2016 BiOp is attached to this opinion as Appendix B.

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 after signature at the NOAA Library Institutional Repository by visiting https://repository.library.noaa.gov/welcome or directly at https://doi.org/10.25923/anj3-vz06. 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 BiOp is described in (NMFS 2016c). Since the 2016 BiOp was issued, the applicants have submitted a revised HGMP (WDFW 2019) to propose an increased production for the Dungeness River coho program on August 14, 2019.

This consultation evaluates effects of the proposed action on ESA-listed Puget Sound Chinook salmon and Puget Sound steelhead and their critical habitat, as described in more detail in Section 2.2. The effects associated with implementation of the Dungeness River Hatchery salmon production on the Hood Canal Summer Chum Salmon ESU were previously evaluated by NMFS when consulting pursuant to ESA section 7 on the eight programs rearing summer chum salmon (NMFS 2002), which determined that that the effects of programs analyzed in the 2016 BiOp had minimal likelihood of adverse effects on Hood Canal summer chum salmon. While the coho production numbers are higher under the current proposed action than that analyzed in NMFS (2002), the effects are within those analyzed in that opinion because the effect of coho salmon being released in the Dungeness River on summer chum salmon is minimal.[1]

1.3. Proposed Federal Action

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

There are two federal action agencies:

- The Proposed Action for the National Marine Fisheries Service (NMFS) is determination under limit 6 of the ESA 4(d) rule for listed Puget Sound Chinook salmon and listed Puget Sound steelhead (50 CFR § 223.203(b)(6)) concerning the hatchery programs in the Dungeness Basin submitted for review by the Washington Department of Fish and Wildlife (WDFW), with the Jamestown S'Klallam Tribe as the *U.S. v. Washington* fish resource co-manager.
- The Proposed Action for the Bureau of Indian Affairs (BIA) is the ongoing disbursement of funds to the Jamestown S'Klallam Tribe for operation and maintenance of the Dungeness River coho program.

NMFS describes a hatchery program as a group of fish that have a distinct purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008c). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004). The coho programs helps meet tribal fishery harvest allocations that are guaranteed through treaties, as affirmed in *U.S. v. Washington*

[1] There are two potential effects hatchery-origin coho can have on natural-origin chum salmon. First, the juvenile hatchery-origin coho could prey upon or compete with natural-origin juvenile chum; such ecological interactions are unlikely because most of the chum salmon in the Dungeness River emerge by the end of April and immediately migrate to the nearshore to rear, and the hatchery-origin coho are not released until May. Second, the returning adult hatchery-origin coho can compete with naturally spawning chum or superimpose its redd over chum redds; this effect is also likely to be minimal because chum in the Dungeness River mostly spawn in the lower 2 miles of the river (NMFS. 2016d. Final Environmental Assessment to Analyze Impacts of NOAA's National Marine Fisheries Service Determination that Three Hatchery Programs for Dungeness River Basin Salmon as Described in Joint State-Tribal Hatchery and Genetic Management Plans Satisfy the Endangered Species Act Section 4(d) Rule. April 2016. NMFS, Seattle, Washington. 175p.), where less than 0.2% of the coho escapement is observed (Haggerty, M. 2019b. Memorandum to Emi Kondo (NMFS) from Mike Haggerty. Dungeness River Hatchery Coho Redd Superimposition. May 6, 2019. 18p.).

(1974) and to help meet Pacific Salmon Treaty harvest sharing agreement with Canada. In addition, the proposed increase is intended to benefit Southern Resident Killer Whale (SRKW) diet.

The Chinook salmon and pink salmon programs described in the proposed action for the 2016 BiOp remain the same for this opinion. The coho program, under the new proposed action analyzed in this opinion, includes a proposed increased production of yearlings to 800,000 fish (from 500,000), which will all be released at the Dungeness Hatchery; all other aspects of the coho program (e.g., broodstock collection methods, water usage, release sites) remain the same as those described in the 2016 BiOp.

The objective of this opinion is to determine the likely effects on ESA-listed salmon and steelhead and their designated critical habitat resulting from these Federal actions. The effects of these actions are subsumed within the operation of these hatchery programs. Therefore, this opinion will determine if the actions proposed by the operators comply with the provisions of sections 7 and 4(d) of the ESA. The duration of the Proposed Action is unlimited for the 4(d) determination. More information on the management of each program follows in the description below.

1.4. Interrelated and Interdependent Actions

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

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

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

2.1. Analytical Approach

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

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

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

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

Range-wide status of the species and critical habitat

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

Describing the environmental baseline

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

Cumulative effects

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

Integration and synthesis

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

Jeopardy and adverse modification

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

Reasonable and prudent alternative(s) to the proposed action

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

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

As described in the 2016 BiOp, the Dungeness River hatchery programs would affect Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) and Puget Sound steelhead (*O. mykiss*). The Puget Sound Chinook Salmon ESU was listed as threatened on March 24, 1999 (64 FR 14508) and its critical habitat designation on September 2, 2005 (70 FR 52360). 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 BiOp was issued, and we consider the descriptions in the 2016 BiOp to still represent the best available science.

2.3. Action Area

The "action area" means all areas to be affected directly or indirectly by the Proposed Action, in which the effects of the action can be meaningfully detected measured, and evaluated (50 CFR 402.02). The action area for this proposed action remains to be the Dungeness River watersheds, its tributaries, and nearshore marine waters of Dungeness Bay, as described in the 2016 BiOp.

As discussed in the 2016 BiOp, NMFS also considered whether the marine areas of Puget Sound outside of Dungeness Bay and in the ocean are affected by the proposed action and therefore should be included in the action area. The potential concerns are relationships between Dungeness River Hatchery salmon production, and mixed stock fisheries harvest, and density-dependent interactions affecting salmon growth and survival in the marine environment. However, NMFS has determined that, based on best available science, it is not possible to establish any meaningful causal connection between hatchery production on the scale anticipated in the proposed action and any such effects.

2.4. Environmental Baseline

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

The environmental baseline associated with habitat described in the 2016 BiOp remains the same, including land use, fish habitat, and water use in the Dungeness River watershed. Habitat restoration projects described in the 2016 BiOp are currently on-going, and no additional habitat restoration activities have been identified, other than those identified in the 2016 BiOp that are funded through the Pacific Coastal Salmon Recovery Fund.

Section 2.2.3 of the 2016 BiOp 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).

2.4.1. Fisheries

There are no directed fisheries for natural-origin or hatchery-origin Chinook or fall-run pink salmon, or natural-origin steelhead in the action area. Dungeness Chinook and fall-run pink salmon are propagated through the proposed hatchery programs for conservation purposes, and contribution to fisheries harvest is not an objective. As described by NMFS (2001); (NMFS 2019a), listed Hood Canal summer chum salmon, Puget Sound Chinook salmon, and steelhead are caught incidentally in fisheries targeting coho salmon and un-listed, hatchery winter steelhead within the action area. Incidental harvest of Dungeness Chinook, Hood Canal summer chum, and Dungeness steelhead in marine areas, outside of this action area, are currently managed to reduce risk to the viability and recovery of these populations and species through separate ESA authorizations— NMFS (2001) for summer chum and (NMFS 2019a) for Chinook and steelhead. Under current ESA-authorized harvest management plans, total incidental fisheries impact on Dungeness River summer chum salmon is limited to a "Base Conservation Rate" of 5% or less of the total annual run size (WDFW and PNPTT 2000). This harvest level is considered sufficiently conservative to allow preservation and restoration of Dungeness River-origin summer chum salmon (NMFS 2001).

To help protect and recover the Dungeness Chinook salmon population, the total allowable annual exploitation rate in all Southern U.S. (SUS) fisheries[2] is limited to 10%. Between 2009 and 2016, actual annual SUS exploitation rates on Dungeness Chinook salmon averaged just 4%. Total harvest rates—SUS and harvest in Canada and Alaska—are higher, averaging 15% over the same period. Seventy-two percent of the harvest of Dungeness Chinook salmon occurs in fisheries in Canada and Alaska. —Although the total harvest rate remains above rebuilding exploitation rate objective (5%), production from the proposed conservation hatchery program buffers short-term demographic risks and preserves the genetic legacy of the population as degraded habitat is recovered.

Although specific incidental impact data are lacking for Dungeness River native steelhead, surrogate terminal steelhead harvest rates were calculated for a set of five reference Puget Sound watersheds for natural-origin steelhead and averaged 1.43 percent annually in Puget Sound fisheries during the 2007/2008 to 2017-2018 time period (NMFS 2019a). Currently, Puget Sound freshwater fisheries are managed to an aggregate, average rate of 4.2 percent. This limit was developed at the time of the Puget Sound steelhead DPS (2007), when NMFS determined that the current harvest management strategy that had eliminated direct harvest of natural-origin steelhead in Puget Sound had largely addressed the threat of decline to the listed DPS posed by harvest (72 FR 26722, May 11, 2007). The rate represents the average harvest rate, across the five reference watersheds, from 2001-02 through 2006-07. The steelhead fishery in the Dungeness River, which targets hatchery-origin fish produce from the proposed action, has only diminished in scale as the hatchery release numbers have been reduced since the Puget Sound Steelhead DPS listing. In summary, and as mentioned in Section 1.3.2, NMFS analyzed the effects of all fisheries on listed Dungeness River watershed salmon and steelhead, and concluded that fisheries harvest actions within and outside of the action area are not likely to jeopardize the continued existence of the Hood Canal summer chum salmon ESU (NMFS 2001), or the Puget Sound Chinook salmon ESU and the Puget Sound Steelhead DPS (NMFS 2019a), or adversely modify designated critical habitat for these listed species.

Within the action area, Jamestown S'Klallam tribal commercial and ceremonial and subsistence fisheries for Dungeness River natural-origin and hatchery-origin coho salmon occur seasonally in Dungeness Bay and the lower Dungeness River, contingent on the availability of natural-origin fish surplus to natural spawning escapement needs. A WDFW-managed non-Indian commercial skiff gillnet fishery in Dungeness Bay also targets returning coho salmon surplus to escapement needs. These fisheries remain as described in the 2016 BiOp.

[2] I.e., Chinook salmon fisheries occurring in Puget Sound and off the Pacific coast of Washington, Oregon, and California.

2.4.2. Hatcheries

Hatchery production in the Dungeness River watershed has remained the same as that analyzed in the 2016 BiOp, which determined that those hatchery production levels do not appreciably reduce the likelihood of survival and recovery of these ESA-listed ESUs and DPSs. Since the 2016 BiOp was completed, the effects of juvenile outmigrant trapping were analyzed and determined not to result in a reduction in the likelihood of survival and recovery of the listed species (NMFS 2017d; NMFS 2018a). For the Puget Sound Steelhead DPS, up to 2% of the juvenile proportion and 6% of the adult proportion of the DPS are anticipated to be handled, with < 1% mortality rate. For the Puget Sound Chinook Salmon ESU, up to 12% of the juvenile proportion and < 1% of the adult proportion are anticipated to be handled, with < 1% mortality rate. We expect these impacts to continue in the same manner during implementation of the proposed action.

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 2015) and was summarized in relevant ESU or DPS specific sections of Section 2.2 of this opinion. In addition, Table 1 summarizes the section 7 consultations that have been completed on other hatchery programs since the 2016 BiOp.

Table 1. Summary of section 7 consultations that have been completed since the 2016 BiOp.

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		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
	FRF Fall Chinook		
	FRF Steelhead		
	Green River Native Late Winter Steelhead		
	Soos Creek Hatchery Summer Steelhead		

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

This section describes the effects of the Proposed Action, independent of the Environmental Baseline and Cumulative Effects. The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized in Appendix A and application of the methodology and analysis of the Proposed Action is in Section 2.4.2. The "effects of the action" means the direct and indirect effects of the action on the species and on designated critical habitat, together with the effects of other activities that are interrelated or interdependent, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the Proposed Action and are later in time, but still are reasonably certain to occur. Effects of the Proposed Action that are expected to occur later in time are included in the analysis in this opinion to the extent they can be meaningfully evaluated. The Proposed Action, the status of ESA-protected species and designated critical habitat, the Environmental Baseline, and the Cumulative Effects are considered together to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA protected species or result in the destruction or adverse modification of their designated critical habitat.

2.5.1. Factors That Are Considered When Analyzing Hatchery Effects

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

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

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

Information that NMFS needs to analyze the effects of a hatchery program on ESA-listed species must be included in an HGMP. Draft HGMPs are reviewed by NMFS for their sufficiency before formal review and analysis of the Proposed Action can begin. Analysis of an HGMP or Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on six factors[3]. 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

[3] 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.

currently limiting population viability. For more information on how NMFS evaluates each factor, please see Appendix A.

2.5.2. Effects of the Proposed Action

This section discusses the effects of the proposed action on the ESA-listed species in the action area. With respect to the effects of the action on the natural-origin Puget Sound Chinook and steelhead populations in the Dungeness River basin, most of the effects remain the same as analyzed in the 2016 BiOp, with the exception of Factors 2 and 3.

While the increased coho production is intended to benefit SRKW diet, the degree to which SRKW would feed on this coho production is unknown. Therefore, in assessing the hatchery factors on natural-origin salmonids, we assume in this analysis that the hatchery fish would return to the Dungeness River watershed at a similar rate as the previous years.

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

The broodstock collection methods for all three programs will be the same as discussed in the 2016 BiOp, and, therefore, the effects will be the same as those analyzed in the 2016 BiOp because the broodstock collection intensity and magnitude will remain the same. To summarize, the 2016 BiOp found that there is a beneficial effect on Chinook salmon genetics and demographics because the Dungeness River Hatchery Chinook Salmon program uses natural-origin Chinook salmon as broodstock to maintain the genetic diversity of the native population, while limiting the removal levels of returning adults consistent with population needs. The 2016 BiOp also found that there are negligible effects on ESA-listed salmon and steelhead from broodstock collection of the Chinook, pink, and coho salmon because measures are applied to adequately safeguard direct and incidental encounters of listed species, with up to 130 Chinook salmon (including 112 collected as broodstock) and 21 steelhead being collected or handled during broodstock collection.

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

Genetic effects on Chinook salmon

The 2016 BiOp found that Dungeness River Hatchery Chinook salmon program has a potential to result in a negative effect on genetic diversity of Puget Sound Chinook salmon populations, including effects from within-population diversity reduction and hatchery-induced selection. The 2016 BiOp indicated that recruits per spawner (R/S) rate, averaged over five consecutive years, is a reliable metric to measure the productivity of the listed Chinook salmon population (therefore, the negative genetic effects on the population) and concluded that the R/S rate for the Dungeness Chinook salmon population is 0.7, using data from 1999 to 2008.

Since the 2016 BiOp, we have compiled a more complete dataset using real (as opposed to derived) numbers. We are now using data from 2004 through 2013 for this analysis because that is the timeframe in which we have a complete empirical dataset. In addition, R/S rate of 0.7 was derived by erroneously counting hatchery-origin Chinook salmon as if they have spawned naturally. By accounting for these issues, updated analysis indicates that spawner-to-spawner productivity[4] is 0.44, which represents the productivity of the natural-origin Chinook population in the Dungeness River (WDFW 2018).

Measures identified to reduce risks to within-population diversity and measures identified to reduce hatchery-induced selection will continue to be implemented. In addition, the co-managers will continue to collect genetic samples to monitor the genetic diversity status of the population and divergence between the hatchery-origin and natural-origin Chinook salmon, as stated in the 2016 BiOp. Because the increased production under the new proposal is only pertinent to the coho program, the analysis in the 2016 BiOp for genetic risks, as corrected here, remains applicable.

Redd superimposition effects on pink salmon

The 2016 BiOp concluded that up to 40% of ESA-listed Chinook salmon in the Dungeness River may be affected by hatchery-origin pink salmon superimposing their redds. We have, since the 2016 BiOp, obtained data to better analyze the likely effects of hatchery-origin pink salmon on the spawning grounds. Pink salmon are collected as broodstock only in years of low abundance to ensure sufficient spawner return in the future to preserve the population’s characteristics, so the program releases hatchery-origin pink salmon following years of low abundance. Furthermore, majority of the hatchery-origin pink salmon (likely around 98%) spawn in Hurd Creek or below RM 3.3 on the Dungeness River (Haggerty 2019a).

Because Hurd Creek is not used by natural-origin Chinook salmon as a spawning ground, the impacts on Chinook salmon redds are expected to occur in the mainstem Dungeness River, below RM 3.3. Of the returning hatchery-origin pink salmon, roughly 58% are likely to spawn in the Dungeness River (below RM 3.3.), while about 42% are likely to spawn in Hurd Creek. Below RM 3.3 also constitutes about 17% of the Dungeness Chinook salmon population spawning, so the 58% hatchery-origin returning pink salmon have the potential to superimpose their eggs over 17% of the Dungeness Chinook salmon population on those years with hatchery-origin pink salmon returns (Haggerty 2019a). In addition, as noted in the 2016 BiOp, the redd superimposition is limited because spawning likely occurs in substantially different locations within the river channel and because Chinook salmon redds are typically buried deeper than the depth of excavation by pink salmon.

Redd superimposition effects on Chinook salmon

New information indicates that hatchery-origin coho salmon may be superimposing their redds[5] on natural-origin Chinook salmon redds (Haggerty 2019b). By using GPS location data of Chinook salmon and coho redds from the previous years, Haggerty (2019b) analyzed the likelihood of coho superimposing redds over Chinook salmon redd in 2 methods; we used 2

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[4] The 2016 BiOp did not clearly specify the type of R/S rate. Because the value of 0.7 in the table cited for that value is a spawner-to-spawner productivity, we specify here that the R/S rate will be measured in terms of spawner-to-spawner productivity.

[5] Because of the difference in spawn timing between coho and Chinook salmon, spawning site competition remains to not be a concern for the coho program.

different methods because of the uncertainty surrounding the GPS accuracy and the shape and direction in which the redds may have been formed. In both analyses, redds were assumed to be circular (rather than elliptical), and the GPS location data accuracy was assumed to have a variation in 15 feet. For both analyses, data from broodyear 2011 and 2012 were used, then extrapolated into the future release level[6].

Method 1 used the GPS location data to estimate the amount of potential redd superimposition based on the proportions of buffered redd areas that intersect. The buffered redd area was calculated around the individual GPS data points, first by taking the radius of an average Chinook salmon and coho redds (100 ft^2 equals to 5.64 ft radius for Chinook; 25 ft^2 equals to 2.82 ft for coho), then adding a 15-foot buffer, resulting in the radius of 20.64 ft and 17.82 ft for Chinook salmon and coho redds, respectively. Then, proportions of Chinook salmon and coho redd area within the area of overlap were used to calculate the likely superimposition area. The area of redd superimposition was summed for the entire watershed, then converted to the lost Chinook subyearling smolt production in a particular year from hatchery-origin coho redd superimposition. Using this method, it was estimated that, on average, 190 subyearling Chinook smolts would be lost due to coho redd superimposition with the proposed release level, resulting in the loss of 1.1 returning adults[7] each year.

Method 2 calculates the area of intersection of two redds based on random redd generation set to range the assumed accuracy of the GPS units used to collect redd position data. Under this method, we first identified all redds that had an area of intersection in Method 1, then modeled 500 random pairs of redds for each set of Chinook and coho redds (with radius of 5.64 ft and 2.82 ft for Chinook and coho, respectively) to land within 15 feet in any direction from the GPS locations. Then, the area of intersection for the 500 random pairs were averaged to generate the area of intersection for one set of Chinook-coho redds. All averaged areas of intersections were summed for the entire watershed, then the same conversion method was used to estimate the lost Chinook subyearling smolt production in a particular year from hatchery-origin coho redd superimposition. Using this method, it was estimated that, on average, 48 subyearling Chinook smolts would be lost due to coho redd superimposition with the proposed release level, resulting in the loss of 0.3 returning adults each year.

While the GPS locations of the redds allow us to estimate the likelihood of hatchery-origin coho redd superimposition to the best of our abilities, several factors likely make these analyses unlikely to accurately predict the effect on Chinook subyearling smolts. Because Method 1 uses proportional buffered redd areas that intersect to estimate the amount of area of redd superimposition, Method 1 may overestimate the amount of redd superimposition; that is, the eggs are in discrete egg pockets confined to a much smaller area and are not proportionally distributed throughout the area of the buffered redds. Method 2 uses random redd construction to estimate the amount of area of redd superimposition, which is unlikely to accurately depict where redds are actually constructed, and the levels of streamflow likely segregates Chinook salmon and coho spawning sites. Moreover, neither methods account for egg burial depth

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[6] While the proposed release level is 800,000 yearlings, our analysis was performed at 880,000 yearlings to account for the 10% cushion in the production level allowed as a buffer against variability in within-hatchery survival; an overage of 10% is anticipated to be a rare occurrence.
[7] The lost smolts were converted to lost returning adults by multiplying the number of smolts by the average subyearling smolt-to-adult return (0.56% for broodyears 2004-2010).

(Chinook salmon is likely to bury their eggs deeper), which may result in overestimating the impact of coho redd superimposition on Chinook salmon.

Marine-derived nutrients

While effects discussed above are negative effects, hatchery returning adults can also provide a benefit to the natural-origin fish. That is, the increased coho production may provide more marine-derived nutrients via adult returns to the Dungeness River watershed, though the amount of marine-derived nutrients would be different depending on the adult return levels and the amount of nutrient enhancement by the applicants. In 2017, for example, the coho program contributed about 23,625 pounds[8] of potential marine-derived nutrient biomass. The amount of marine-derived nutrients is anticipated to be higher because of the production increase, though how much it would increase is uncertain. Because all other production numbers remain the same, the analysis in the 2016 BiOp for the Chinook and pink salmon programs remains applicable.

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

Hatchery release competition and predation effects

The 2016 BiOp concluded that hatchery-origin juvenile Chinook salmon (both subyearling and yearling) and yearling coho salmon would have competitive interactions with natural-origin juvenile Chinook salmon and steelhead because of the spatial and temporal overlap in the Dungeness River (see Table 13 in the 2016 BiOp), though releasing the subyearling Chinook salmon in late spring would reduce temporal overlap with natural-origin juvenile fish.[9] Similarly, the 2016 BiOp concluded that the hatchery-origin juvenile Chinook and coho salmon would prey on natural-origin juvenile Chinook salmon and steelhead because of spatial and temporal overlap, though the level of predation would be limited by the size of the hatchery releases; therefore, predation effects were limited to effects from hatchery-origin yearling Chinook and coho salmon. The proposed increase in release size of coho salmon requires a re-examination of the potential effects of predation.

The co-managers have included measures designed to minimize competition and predation risks in the Dungeness River, such as release locations in lowest portion of the watershed and monitoring for release timing to minimize temporal overlap with natural-origin juvenile fish. All fish would continue to be released in healthy condition as seawater-ready, migrating smolts to ensure rapid emigration downstream through watershed areas where interactions with rearing listed fish may occur. The 2016 BiOp concluded that the proportion of all hatchery-origin and natural-origin juvenile salmon and steelhead emigrating seaward in the Dungeness River downstream of the hatchery release sites on or after the 10th day after the last release of hatchery-origin Chinook salmon and coho salmon, respectively, that is represented by hatchery-origin

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[8] In 2017, the estimated smolt to naturally spawning adult was 0.045%, equating to about 247 hatchery-origin coho naturally spawning (0.00045 x 550,864). In addition, 3,128 adults were returned to the river through a nutrient enhancement program. A total of 3,375 (247+3,128) coho equates to about 23,625 pounds of biomass, at about 7 pounds per adult coho.

[9] Hatchery-origin pink salmon (released as fry) would not have a negative effect on natural-origin juvenile Chinook salmon and steelhead because of the difference in habitat and diet preference.

Chinook salmon or coho salmon would remain less than 10 percent, with 90% outmigrating sooner. This would substantially limit the amount of competition and predation effects that would occur as a result of the proposed action. While the coho salmon production is increased to 800,000 yearlings, this proportion is expected to remain the same. With the increase of 300,000 yearlings, less than 30,000 yearlings more than that analyzed in the 2016 BiOp are expected to remain in the system to compete with or prey on natural-origin juvenile fish; the impacts will continue to be minimized because the hatchery release strategy will minimize temporal overlap with natural-origin juvenile fish.

The 2016 BiOp also concluded that it is not possible to meaningfully measure, detect, or evaluate the specific effects of Dungeness River Hatchery-origin juvenile and adult salmonid production on listed species in Puget Sound and the Pacific Ocean, due to the low magnitude of, and low likelihood for, effects in those locations. This conclusion remains the same with the increased coho production because, even with the increased production, the expected adult return for the coho program is 11,748 adults (Haggerty 2019c), which remains comparable to the average adult return described in Table 14 of the 2016 BiOp.[10] Therefore, the increased production still contributes to an unsubstantial change in the total number of anadromous salmonids encountered by listed species in Puget Sound and Pacific Coastal marine waters outside of the Dungeness River, and all of the production in the Dungeness River watershed remains an unsubstantial portion of the total abundance of each species present in Puget Sound and Pacific Coastal marine areas.

Naturally-produced progeny competition

Naturally spawning hatchery-origin salmon and steelhead are likely to be less efficient at reproduction than their natural-origin counterparts (Christie et al. 2014), but the progeny of such hatchery-origin spawners are likely to make up a sizable portion of the juvenile fish population for those areas where hatchery-origin fish are allowed to spawn naturally. This is actually a desired result of the integrated recovery programs. Therefore, the only expected effect of this added production is a density-dependent response of decreasing growth and increased competition/predation as habitat capacity is approached, as would occur in any system. However, this natural phenomenon is a potential concern in this case because the steelhead and Chinook salmon in the basin are listed.

Because coho salmon historically coexisted in substantial numbers with Chinook salmon and steelhead, it follows that there must have been adequate passage and habitat to allow all species to be productive and abundant. It does not follow automatically, however, that the historical situation can be restored under present-day conditions where habitat conditions have changed considerably over time, as they have in the Dungeness basin. This issue has received considerable attention in the Upper Columbia River basin, where coho salmon are now being reintroduced following their extirpation decades ago. A considerable body of research is now available that suggests that the different salmonid species tend to occupy different micro-habitats (discussed in detail with many citations in NMFS 2014), which greatly reduces the potential for competitive and density impacts. Should the situation arise where salmon and steelhead

[10] Of note, the expected adult return for the proposed increase is less than that analyzed in the 2016 BiOp because return estimate is calculated using information that includes more recent years.

production is limiting natural production of listed salmon species, recovery planners would have to prioritize species. However, NMFS expects that the monitoring efforts via juvenile screw trapping would detect negative impacts before they reach problematic levels.

Disease

The risk of pathogen transmission to natural-origin salmon and steelhead is negligible for these hatchery programs. This is because no detections of exotic pathogens have occurred in the last three years and epidemics have all been caused by endemic pathogens with available treatments (Table 2). Diseases that could be caused by pathogens outlined in Table 2 were treated accordingly (e.g., medicated feed, formalin) (Kondo 2019).

Table 2. Pathogen detections in Chinook, coho, and pink salmon reared by the Dungeness River salmon hatchery programs.

Facility	**Pathogen Detected**		
	2016	**2017**	**2018**
Dungeness Hatchery Coho	Diatoms; *Flavobacterium pychrophilum*	Diatoms	Diatoms
Dungeness Hatchery Spring Chinook	None	None	None
Hurd Creek Hatchery Spring Chinook	None	None	None
Hurd Creek Hatchery Fall Pinks	N/A	None	N/A
Upper Dungeness Acclimation site: Dungeness Chinook	None	None	None
Gray Wolf Acclimation site: Dungeness Chinook	None	None	None

Furthermore, to prevent outbreaks and reduce the amplification of IHNV in natural environments, hatchery staff drain the coelomic fluid from females during spawning and treat eggs with an iodophor solution, controlling, to some extent, the transmission of IHNV(IHOT 1995; NWIFC and WDFW 2006; ODFW 2003; PNFHPC 1989). Because of these preventative measures, no epidemics of IHNV associated with these programs have occurred in recent years. Thus, NMFS believes the risk of pathogen transmission to wild fish from hatchery fish, and amplification of pathogens in the natural environment, is low.

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

As described in Section 2.4, juvenile outmigrant trapping associated with these programs were analyzed determined not to result in a decrease in the likelihood of survival and recovery of the listed species in NMFS (2018a) and in NMFS (2017d). Other activities, such as direct observation and carcass surveys, remain the same as analyzed in the 2016 BiOp and are expected to cause avoidance behaviors that are within the range of normal predator and disturbance behaviors.

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

The 2016 BiOp concluded that the majority of the water supply systems used for salmon rearing in the proposed programs are designed and operated such that groundwater extraction and surface water withdrawals do not cause adverse effects on ESA-listed salmon and steelhead. However, the 2016 BiOp noted that the water intake structures in the Dungeness River, Canyon Creek, and Hurd Creek did not meet NMFS intake screening nor fish passage criteria. Since the 2016 BiOp, a fish ladder and an intake screen were installed at the structure in Canyon Creek.

The water intake structures at Hurd Creek (screening only) and the Dungeness River Hatchery (screening and fish passage) are in the process of being modified and are expected to be finished by the fall of 2022. Regarding the ongoing operational effects, while there have been no fish passage problems or fish mortality because of the current water intake structures that are being modified, NMFS considers the Dungeness River Hatchery structure to pose unsubstantial risks to fish passage, as discussed within the 2016 BiOp. In addition, the current intake screens at the Dungeness River Hatchery meets the 2008 screening criteria, which is adequately protective of listed Chinook salmon and steelhead from impingement and entrainment effects until the structures are renovated (NMFS 2008a; NMFS 2011a). For Hurd Creek, the 2016 BiOp concluded that adverse effects on migrating salmonids are unlikely, primarily because of the structures' configuration and location and how it is operated. Currently, the intake structures affect a very small proportion of total fish habitat available to salmon and steelhead in the watershed. The mainstem intakes present risks of entrainment for juvenile fish in no more than a total of 4 square meters of migration and rearing area adjacent to the intakes. Once completed, as considered in a separate, pending consultation, both the Dungeness River Hatchery and Hurd Creek water intake structures will meet the relevant NMFS criteria for screens and fish passage.

The total amount of surface water used for the hatchery facilities is not thought to lead to any substantial effects on listed fish. As discussed within the 2016 BiOp, fish biomass in the hatcheries would reach maximum permitted levels only in the late winter and spring months just prior to fish release dates, which is when the facilities would withdraw the maximum amount of water; this maximum level of biomass corresponds with the time when flows in river and tributary sources reach annual maximums (see Figure 11 in the 2016 BiOp). Because of the timing of minimum water usage at the hatcheries, stream reaches would not be dewatered to the extent that natural-origin fish migration and rearing would be impaired, and there would be no net loss in river or tributary flow volumes because flows are returned near the withdrawals.

The discharge from increased coho production at the Dungeness River Hatchery is not likely to have additional effects on water quality beyond what was analyzed in the 2016 BiOp. The total facility discharges proportionally small volumes of water with waste (predominantly biological waste) into a larger water body, which results in temporary, very low, or undetectable levels of contaminants. General effects of various biological wastes in hatchery effluent are summarized in NMFS (2004a), though the biological waste from the proposed activities is not likely to have a detectable effect on listed species because much of the biological waste will continue to be removed from the effluent prior to discharge. The Dungeness River Hatchery operates an off-line settling pond and artificial wetland to remove effluent before the water is released back into the Dungeness River. All other discharge will remain the same as analyzed in the 2016 BiOp, which concluded that the effects of hatchery effluent discharge on listed Chinook salmon and steelhead have been adequately minimized through compliance with federal and state permit requirements, such as the NPDES permit, and the requirements will remain the same as analyzed in the 2016 BiOp.

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

All broodstock collection methods will remain the same as analyzed in the 2016 BiOp. Because Chinook and coho salmon broodstock are predominantly volunteers to the Dungeness River Hatchery, and the facility is off-channel and removed from listed Chinook salmon and steelhead migration and rearing areas, the 2016 BiOp concluded that collection of broodstock would not substantially affect migration or spatial distribution of natural-origin juvenile and adult Chinook salmon and steelhead. However, listed Chinook salmon adults are affected by the mainstem Dungeness River (Game Farm) weir at RM 2.5 (when operating), and (only if needed) through netting, gaffing, noodling, or snagging implemented to collect broodstock in the lower river. The 2016 BiOp concluded that any effects from these actions could be minimized through implementing best management practices outlined in the 2016 BiOp, and the magnitude of such encounters are described above in Section 2.5.2.1.

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

There are no fisheries that exist because of the Proposed Action. Fisheries in the action area are subject to consultation on an annual or multi-year basis, depending on the duration of the Puget Sound fishery management plan submitted by the co-managers. As described in Section 2.4.4, Environmental Baseline, the effects of all fisheries on ESA-listed species are expected to continue at similar levels to those described in the Environmental Baseline. NMFS (2016a);

NMFS (2017a) found that the fisheries will not appreciably reduce the likelihood of survival and recovery for the listed species.

2.5.3. Effects of the Action on Critical Habitat

The proposed increase in the coho program will not have additional effects on critical habitat than those described in the 2016 BiOp. Existing hatchery facilities have not led to: altered channel morphology and stability; reduced and degraded floodplain connectivity; excessive sediment input; or the loss of habitat diversity. No new facilities or construction are directly proposed as part of the proposed actions considered in this opinion.

As discussed in the 2016 BiOp, proposed surface water diversion for rearing juvenile salmon would not affect the spatial distribution of adult or juvenile ESA-listed Dungeness River Chinook salmon or steelhead. Permitted water withdrawal levels for fish rearing are usually a small fraction of average annual flows in freshwater areas where listed fish may be present, and water withdrawn for hatchery use is returned near the points of withdrawal. Hatchery diversion screens protect listed juvenile Chinook salmon and steelhead from entrainment and injury, and meet current NMFS screen criteria, or are proposed for retrofitting to meet those criteria as needed (See Section 2.5.2.5).

Compliance with NPDES permits issued for the programs would continue to help ensure that water quality in downstream areas where listed fish may be present is not degraded. Effluent discharge for the hatchery operations is not expected to degrade water quality. Consistent with effluent discharge permit requirements developed by the Environmental Protection Agency and the Washington Department of Ecology for upland fish hatcheries, water used for fish production at the Dungeness River Hatchery would be adequately treated prior to discharge into downstream areas to ensure that federal and state water quality standards for receiving waters are met and that downstream aquatic life, including salmon and steelhead, will be no more than minimally affected.

No hatchery maintenance activities are proposed in the HGMPs that would adversely modify designated critical habitat.

For these reasons, the proposed hatchery programs are not expected to pose substantial risks through water quality impairment to downstream aquatic life, including listed salmon and steelhead. No hatchery operation and maintenance activities are expected to adversely modify designated critical habitat or habitat proposed for critical designation.

2.6. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). 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.

The federally approved Shared Strategy for Puget Sound recovery plan for Puget Sound Chinook Salmon (SSPS 2007) describes, in detail, the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to listed Puget Sound Chinook salmon in the Dungeness River watershed. A recovery plan for Puget Sound steelhead in the watershed is currently in draft form (NMFS 2018b), but many of the actions implemented for Chinook salmon recovery will also benefit steelhead. 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. 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. However, we expect the activities identified in the baseline to continue at similar magnitudes and intensities as in the recent past.

On-going State, tribal, and local government salmon restoration and recovery actions implemented through plans such as the recovery plans (NMFS 2018b; 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, however, 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).

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

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS adds the effects of the Proposed Action (Section 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.

2.7.1. Puget Sound Chinook Salmon ESU

As discussed in the 2016 BiOp, best available information indicates that the Puget Sound Chinook Salmon ESU remains threatened (NWFSC 2015). The Dungeness population is one of the populations ranked for its primary importance for preservation, restoration, and recovery of the Puget Sound ESU (NMFS 2010). Our environmental baseline considers the effects of dams, habitat condition, fisheries, and hatcheries on Puget Sound Chinook Salmon, of which fisheries and hatcheries have new effects since the 2016 BiOp that were considered.

The effects of our proposed action on this ESU beyond those included in the baseline include effects from direct or incidental encounters during broodstock collection, genetic effects, ecological effects from hatchery-origin adult returns and from hatchery-origin juvenile outmigrants, and effects from intake structures in Dungeness River and Hurd Creek.

As discussed in the 2016 BiOp, up to 130 Chinook salmon (including 112 collected for broodstock) will be collected and handled during broodstock collection, with no expected mortality. The effect remains to be overall a benefit to the ESU because natural-origin fish are included as broodstock to maintain the genetic diversity of the native population, while limiting the removal levels of returning adults. In addition, the risks to fish encountered in excess of the broodstock needs will be minimally affected through application of measures to adequately safeguard the handled fish.

The Chinook salmon program has a potential to result in a negative effect on genetic diversity of Puget Sound Chinook salmon populations, and therefore to the ESU, including effects from within-population diversity reduction and hatchery-induced selection. Updated data indicates that the Dungeness Chinook salmon population, on average, has a recruits per spawner (i.e., spawner-to-spawner) rate of 0.44, which indicates the level of productivity for this population (i.e., how productive the population is with the negative genetic effects on the population). Measures identified to reduce risks to within-population diversity and measures identified to reduce hatchery-induced selection will continue to be implemented. In addition, the co-managers will continue to collect genetic samples to monitor the genetic diversity status of the population and divergence between the hatchery-origin and natural-origin Chinook salmon.

The pink salmon program and the coho salmon program have a potential to result in negative ecological effects on natural-origin fish during the adult return phase. Updated data indicates that the returning hatchery-origin pink salmon can competing for spawning ground with up to 17% of the spawning Chinook salmon in the Dungeness population and potentially superimposing redds on Chinook salmon redds during years with returning hatchery-origin pink salmon. For the coho salmon program, redd superimposition may affect up to 190 subyearling Chinook smolts from the coho redd superimposition with the proposed release level, which equates to the loss of 1.1 returning adults each year. However, the redd superimposition by both pink and coho salmon is likely lower than these estimates because spawning likely occurs in substantially different locations within the river channel and because Chinook salmon redds are likely to be buried deeper than the depth of excavation by pink and coho salmon.

However, returning hatchery-origin adults can also provide a benefit to the Chinook salmon population in the Dungeness River by providing marine-derived nutrients to the system, though the amount would vary from year to year depending on the level of adult returns.

As discussed in the 2016 BiOp, hatchery-origin juveniles are likely to compete with and prey upon natural-origin juvenile Chinook salmon as they migrate out of the Dungeness River because of spatial and temporal overlap, though releasing the subyearling Chinook salmon in late spring would reduce the temporal overlap with natural-origin Chinook salmon. Based on size and lifestage, predation by hatchery-origin fish would likely only result from yearling Chinook and coho salmon. The co-managers continue to implement measures designed to minimize competition and predation risks in the Dungeness River, such as release locations in lowest portion of the watershed and monitoring for release timing to minimize temporal overlap with natural-origin juvenile fish. The proportion of all hatchery-origin and natural-origin juvenile salmon and steelhead emigrating seaward in the Dungeness River downstream of the hatchery release sites on or after the 10^{th} day after the last release of hatchery-origin Chinook salmon and coho salmon, respectively, that is represented by hatchery-origin Chinook salmon or coho salmon is expected to remain less than 10 percent.

The water intake structures at Hurd Creek (screening only) and the Dungeness River Hatchery (screening and fish passage) are expected to have a potential negative effect on listed Chinook salmon. As discussed in the 2016 BiOp, the current intake screens at the Dungeness River Hatchery is adequately protective of listed Chinook salmon from impingement and entrainment effects until the structures are renovated. Currently, the intake structures at both Hurd Creek and the Dungeness River Hatchery affect a very small proportion of total fish habitat available to salmon and steelhead in the watershed. The mainstem intakes present risks of entrainment for juvenile fish in no more than a total of 4 square meters of migration and rearing area adjacent to the intakes. While there have been no fish passage problems or fish mortality because of the current water intake structures that are being modified at the Dungeness River Hatchery structure, NMFS considers those Hatchery structures to pose unsubstantiated risks to fish passage. Once completed in fall of 2022, both the Dungeness River Hatchery and Hurd Creek water intake structures will meet the relevant NMFS criteria for screens and fish passage.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plans for the ESU describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed Chinook salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed salmon ESU. NMFS expects this trend to continue and could lead to increases in abundance, productivity, spatial structure and diversity.

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

2.7.2. Puget Sound Steelhead DPS

As discussed in the 2016 BiOp, best available information indicates that the Puget Sound Steelhead DPS remains threatened (NWFSC 2015). Our environmental baseline considers the effects of dams, habitat condition, fisheries, and hatcheries on Puget Sound steelhead, of which fisheries and hatcheries have new effects since the 2016 BiOp that were considered.

The effects of our proposed action on this DPS beyond those included in the baseline are limited to incidental encounters during broodstock collection, ecological effects from hatchery-origin juvenile outmigrants, and effects from intake structures in Dungeness River and Hurd Creek.

As discussed in the 2016 BiOp, up to 21 steelhead are expected to be handled during broodstock collection, with no expected mortality. However, the risks to fish encountered in excess of the broodstock needs will be minimally affected because of application of measures to adequately safeguard the handled fish.

As discussed in the 2016 BiOp, hatchery-origin juveniles are likely to compete with and prey upon natural-origin juvenile steelhead as they migrate out of the Dungeness River because of spatial and temporal overlap. Based on size and lifestage, predation by hatchery-origin fish is limited to yearling Chinook and coho salmon. The co-managers continue to implement measures designed to minimize competition and predation risks in the Dungeness River, such as release locations in lowest portion of the watershed and monitoring for release timing to minimize temporal overlap with natural-origin juvenile fish. The proportion of all hatchery-origin and natural-origin juvenile salmon and steelhead emigrating seaward in the Dungeness River downstream of the hatchery release sites on or after the 10^{th} day after the last release of hatchery-origin Chinook salmon and coho salmon, respectively, that is represented by hatchery-origin Chinook salmon or coho salmon is expected to remain less than 10 percent.

The water intake structures at Hurd Creek (screening only) and the Dungeness River Hatchery (screening and fish passage) are expected to have a potential negative effect on listed steelhead.

As discussed in the 2016 BiOp, the current intake screens at the Dungeness River Hatchery is adequately protective of listed steelhead from impingement and entrainment effects until the structures are renovated. Currently, the intake structures at both Hurd Creek and the Dungeness River Hatchery affect a very small proportion of total fish habitat available to salmon and steelhead in the watershed. The mainstem intakes present risks of entrainment for juvenile fish in no more than a total of 4 square meters of migration and rearing area adjacent to the intakes. While there have been no fish passage problems or fish mortality because of the current water intake structures that are being modified at the Dungeness River Hatchery structure, NMFS considers those Hatchery structure to pose unsubstantiated risks to fish passage. Once completed in fall of 2022, both the Dungeness River Hatchery and Hurd Creek water intake structures will meet the relevant NMFS criteria for screens and fish passage.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plans for each DPS describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed steelhead DPSs. NMFS expects this trend to continue and could lead to increases in abundance, productivity, spatial structure and diversity.

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

2.7.3. Critical Habitat

The proposed increase in the coho program will not have additional effects on critical habitat than that described in the 2016 BiOp. In the 2016 BiOp, NMFS has determined that the proposed action will not degrade habitat designated as critical for listed fish. The existing hatchery facilities have not led to altered channel morphology and stability, reduced or degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity, and no new facilities or changes to existing facilities are proposed. The proposed actions include compliance with limits and strict criteria for withdrawing and discharging water used for fish rearing, and the actions will continue to not result in any adverse modification of critical habitat. In addition, a fish ladder and an intake screen were installed at the structure in Canyon Creek since the 2016 BiOp, and water intake structures in the Dungeness River and Hurd Creek does not meet NMFS intake screening and the fish passage criteria.

The 2016 BiOp also found that the proposed action will not degrade habitat designated as critical habitat in light of climate change. The proposed Dungeness River Hatchery Chinook salmon program is expected to continue helping attenuate climate change impacts over the short term by providing a refuge from adverse effects for the propagated species through circumvention of potentially adverse migration, natural spawning, incubation, and rearing conditions. Additional access to several miles of Canyon Creek resulting from the construction of a fish ladder may also provide a small buffer to climate effects by providing additional spawning and rearing capacity.

2.8. Conclusion

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

2.9. Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass[11], 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.

This Incidental Take Statement contains much of what was in the 2016 BiOp, is repeated in its entirely here for completeness, and incorporates the take associated with the proposed increased release level of the coho program.

2.9.1. Amount or Extent of Take

The primary form of take of ESA-listed Chinook salmon is direct take, authorized under the 4(d) rule. However, NMFS also expects incidental take of ESA-listed salmon and steelhead will occur as a result of the proposed action for the following factors. The take pathways discussed below are:

- Handling of adults at adult collection facilities
- Genetic and ecological effects of hatchery adults on the spawning grounds
- Ecological effects of juveniles during emigration
- Facility effects of water intake structures

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

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

During broodstock collection, up to 18 ESA-listed Chinook salmon and 21 ESA-listed steelhead are expected to be handled. No mortality is expected from handling of the fish. In addition, 112 Chinook salmon would be intentionally collected, retained, spawned, and killed for use as broodstock.

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

Implementation of the Dungeness River Hatchery Chinook salmon program has the potential to result in some degree of genetic change and fitness reduction in hatchery fish produced through the program, in the progeny of naturally spawning hatchery fish, and in the natural population relative to the baseline diversity and productivity status of the Dungeness Chinook salmon population. Consistent with the integrated conservation intent of the proposed supportive breeding effort, listed Chinook salmon adults would be taken into the hatchery as broodstock, exposing the propagated component of the population to hatchery-influenced genetic effects. Fish produced by the program would also escape to spawn naturally in areas where hatchery-origin and natural-origin will commingle at high hatchery-origin spawner proportions, potentially leading to unintended genetic effect through interbreeding.

It is not possible to ascertain the exact amount of take by genetic effects related to hatchery fish spawning naturally, because it is not possible to meaningfully measure the number of interactions, nor their precise effects. Therefore, NMFS will rely on a surrogate take indicator that measures the productivity of the listed population – a primary factor in determining genetic diversity and fitness reduction effects. It should be noted that the productivity goals may go unmet for a variety of reasons apart from hatchery-related genetic effects (most notably, the degraded state of freshwater habitat in the basin, and the effects of climate change on ocean productivity), but the selected indicator would trigger further analysis to determine the causes of low productivity, with effects attributed to the hatchery program considered commensurately with other factors (e.g., habitat-related conditions and harvest-related effects). NMFS will rely on the estimated recruits per spawner (R/S) (i.e., spawner-to-spawner) rate averaged over five consecutive years as a surrogate take indicator that relates to the productivity of the listed Chinook salmon population. The 2004-2013 estimated average spawner-to-spawner recruits for the Dungeness Chinook salmon population is 0.44 (WDFW 2018), so NMFS will apply a rate of 0.44 spawner-to-spawner recruits, calculated annually as a five-year rolling average, as the surrogate take indicator for genetic effects.

The pink salmon program and the coho salmon program also have a potential to result in negative ecological effects from returning hatchery-origin adults. Returning hatchery-origin pink salmon can compete for spawning ground with up to 17% of the spawning Chinook salmon in the Dungeness population and potentially superimposing redds on Chinook salmon redds during those years with returning hatchery-origin pink salmon. For the coho salmon program, redd superimposition may affect up to 190 subyearling Chinook smolts, which would be lost due to coho redd superimposition with the proposed release level, which equates to the loss of 1.1 returning adults each year.

The take estimates described above associated with spawning ground competition and redd superimposition can be reliably monitored via spawning ground surveys to track incidences of hatchery pink and coho salmon displacing or adversely affecting listed Chinook salmon through these pathways.

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

NMFS has determined that juvenile hatchery-origin Chinook and yearling coho salmon compete with and prey upon rearing and migrating natural-origin Chinook salmon and steelhead in freshwater areas downstream of the release sites. As described in Section 2.5.2.3, hatchery-origin Chinook and coho salmon may overlap spatially and temporally with natural-origin Chinook salmon and steelhead juveniles as hatchery-origin fish exit the Dungeness River seaward; competition between natural-origin and hatchery-origin fish would occur for food and space, and predation would occur if listed Chinook salmon and steelhead juveniles are sizes vulnerable to predation while outmigrating. To reduce the risk of spatial and temporal overlap between juvenile hatchery-origin and listed natural-origin fish that might lead to competition effects, hatchery management practices would be implemented to minimize the duration of interaction between newly released hatchery-origin Chinook salmon and yearling coho salmon and natural-origin Chinook salmon and steelhead.

It is not possible to quantify the take associated with competition in the action area, because it is not possible to meaningfully measure the number of interactions between hatchery-origin Chinook and coho salmon and natural-origin Chinook salmon and steelhead juveniles. Therefore, NMFS will rely on a surrogate take indicator that relates to the proportion of the total abundance of emigrating juvenile salmonids comprised of hatchery-origin Chinook salmon or coho salmon in the lower Dungeness River for the period after the hatchery fish are released. The surrogate take indicator is a proportion of all hatchery- and naturally-produced juvenile salmon and steelhead emigrating seaward in the Dungeness River downstream of the hatchery release sites on or after the 10th day after the last release of the hatchery-origin Chinook salmon and coho salmon, respectively, that is represented by hatchery-origin Chinook salmon or coho salmon; this proportion should remain smaller than 10 percent.

The proportion of hatchery-origin Chinook salmon or coho salmon versus total juvenile fish abundance will be calculated by statistical week, commencing 10 days post-hatchery release and continuing until no hatchery-origin Chinook salmon and coho salmon are captured, as identified either through expanded estimates or catch per unit effort (CPUE). This standard has a rational connection to the amount of take expected from ecological effects, since the co-occurrence of hatchery-origin and natural-origin fish is a necessary pre-condition to competition, and the assumption that, the greater ratio of hatchery fish to natural-origin fish, the greater likelihood that competition will occur. This proportion of hatchery fish in the rearing areas will be monitored by standing co-manager juvenile out-migrant screw trap monitoring activities.

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

The existing Dungeness River Hatchery water intake structures on the Dungeness River mainstem and Hurd Creek may lead to the take of Puget Sound Chinook salmon and Puget

Sound steelhead. Because take by water intake structures occurs in the water and effects of delay or impingement may not be reflected until the fish have left the area of the structure, it is not possible to quantify the level of take associated with operation of the current water intake structures. Therefore, NMFS will rely on a surrogate take indicator in the form of the amount of habitat affected by the intake structures. Currently, the intake structures affect a very small proportion of total fish habitat available to salmon and steelhead in the watershed. The mainstem intakes present risks of entrainment for juvenile fish in no more than a total of 4 square meters of migration and rearing area adjacent to the intakes. This take can be reliably measured by continuing to observe effects associated with the water intakes.

2.9.2. Effect of the Take

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

2.9.3. Reasonable and Prudent Measures

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

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

1. Ensure that the effects on Dungeness Chinook salmon genetic diversity associated with implementation of the Dungeness River Hatchery Chinook salmon program are minimized.
2. Ensure that spawning ground competition and redd superimposition effects caused by Dungeness River Hatchery pink and coho salmon are minimized.
3. Ensure that hatchery water intake structures are operated in such a way as to be adequately screened and provide unimpeded upstream and downstream migration for listed Chinook salmon and steelhead.
4. Ensure that broodstock collection operations do not adversely impact natural-origin steelhead.
5. Implement the hatchery programs as described in the three salmon HGMPs and monitor their operation.
6. Indicate the performance and effects of the hatchery salmon programs, including compliance with the Terms and Conditions set forth in the opinion, through completion and submittal of annual reports.

2.9.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and NMFS must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). Action Agencies have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement

(50 CFR 402.14). If the entity to whom a term and condition is directed does not comply, NMFS would consider whether it is necessary to reinitiate consultation. The Action Agencies (NMFS and BIA) shall:

1a. Ensure that annual surveys are conducted to determine the migration timing, abundance, distribution, and origin (hatchery- and natural-origin) of Chinook salmon spawning naturally and escaping to hatchery release sites in the Dungeness River watershed. The co-managers shall submit any revisions of protocols described in the proposed HGMPs for annual spawning ground surveys and biological sampling for NMFS concurrence on or before June 1 of each year.

1b. Ensure that demographic, morphometric, mark/tag, and/or genetic data are collected, and analyses are conducted, necessary to indicate the total annual adult contribution, by origin, of Dungeness Chinook salmon to fisheries and escapement.

1c. Ensure that the interim and final take surrogates for genetic effects are monitored. For the interim period, co-managers shall submit egg-to-migrant survival compared to expected egg-to-migrant survival. For the final take surrogate, starting in year 2021, co-managers shall submit the recruits per spawner (R/S) (i.e., spawner-to-spawner) rate averaged over five consecutive years, which shall not be lower than 0.44.

1d. Ensure that annual reports are submitted by the co-managers to NMFS, including estimates of natural and hatchery escapement levels, contributions to fisheries for natural and hatchery-origin Dungeness Chinook salmon, and estimates of total recruit per spawner levels for the period when the hatchery Chinook salmon program is implemented (see item 6., below).

2a. Ensure that annual surveys are conducted to determine the migration timing, abundance, and distribution of Dungeness River Hatchery pink salmon that spawn naturally relative to naturally spawning Chinook salmon migration timing, abundance, and distribution. The co-managers shall submit any revisions of protocols described in the proposed HGMPs for annual spawning ground surveys for NMFS concurrence on or before June 1 of each year.

2b. Ensure that annual surveys are conducted to determine the location and extent of any superimposition of Chinook salmon redds by hatchery-origin pink salmon and levels of hatchery-origin pink salmon spawning in Chinook salmon natural spawning areas. As part of this monitoring, the co-managers shall report the annual pHOS and observations of pink salmon displacing or adversely affecting Chinook salmon.

2c. Ensure that annual surveys are conducted to determine the location and extent of any superimposition of Chinook salmon redds by hatchery-origin coho salmon and levels of hatchery-origin coho salmon spawning in Chinook salmon natural spawning areas. As part of this monitoring, the co-managers shall track Chinook and coho redd locations through GPS data annually when streamflow is less than 300 cfs. Redd superimposition from the coho program will be tracked in a rolling average of minimum of 4 out 5 years on the percentage of smolts out migrating, and estimated loss of juvenile Chinook migrants is not anticipated to exceed 2% of the outmigrating natural-origin juvenile Chinook salmon; if the data indicates exceedance, the co-managers will notify NMFS. If data cannot be obtained for more than 1 year out of the last 5 years due to stream flow, applicants shall notify NMFS. The co-managers shall report: (1) the estimated number of juveniles lost using Method 1 (see section 2.5.2.2), (2) the number of outmigrating smolts, and (3) results of (1) divided by results of (2).

2d. Ensure that annual reports are submitted by the co-managers to NMFS describing results of pink salmon and coho salmon spawner surveys described in 2a, 2b, and 2c (see item 6., below).

3a. Ensure that all intake structures supplying water for the three Dungeness River Hatchery programs comply with the NMFS Anadromous Salmonid Passage Facility Design criteria (NMFS 2011a) by fall 2022.

3b. Ensure that the co-managers monitor and annually report hatchery facility compliance with NMFS fish passage criteria (see item 6, below).

3c. Ensure that the co-managers survey migration conditions in the bypass reaches between the Dungeness River Hatchery water intake structures on the Dungeness River and Canyon Creek, and notify the NMFS SFD, within 24 hours, of any injuries, mortalities, or blockages or delays in upstream and downstream migration observed in juvenile or adult Chinook salmon and steelhead.

4a. Ensure that the co-managers immediately release unharmed any natural-origin steelhead incidentally encountered in the course of salmon broodstock collection operations at the point of capture. Hatchery-origin steelhead, identifiable by a clipped adipose fin, that are collected during salmon broodstock collection operations shall be removed and not returned to the river to reduce the threat of genetic and ecological effects on the native Dungeness River steelhead population.

4b. Ensure that the co-managers monitor and annually report the number, location, and disposition of any steelhead encountered during salmon broodstock collection operations (see item 6. below).

5. Ensure that the hatchery programs are implemented as described in the HGMPs and 2019 addenda, including marking and/or tagging of all juvenile salmon released through the programs. NMFS’s Sustainable Fisheries Division (SFD) must be notified in advance of any change in hatchery program operation and implementation that potentially would result in increased take of ESA-listed species. As part of this monitoring, the co-managers shall report the proportion of hatchery-origin Chinook salmon or coho salmon versus total juvenile fish abundance calculated by statistical week, commencing 10 days post-hatchery release and continuing until no hatchery-origin Chinook salmon and coho salmon are captured, as identified either through expanded estimates or catch per unit effort (CPUE).

6. Provide one comprehensive annual report to NMFS SFD on or before April 1st of each year that includes the RM&E actions described in the above Term and Conditions. The

numbers of hatchery-origin salmon released – by age/stage, release dates, and release location – and tag/mark information, encounters with other species, and other information pertinent to program operation effects on ESA-listed resources shall be included in the annual report. All reports, as well as all other notifications required, shall be submitted electronically to the SFD point of contact for this program: Morgan Robinson (*morgan.robinson@noaa.gov*). Annual reports may also be submitted in written form to:

NMFS – Sustainable Fisheries Division
Anadromous Production and Inland Fisheries Program
1201 N.E. Lloyd Boulevard, Suite 1100
Portland, Oregon 97232

2.10. Conservation Recommendations

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

1. The co-managers, in cooperation with the NMFS and other entities, should investigate the relative reproductive success, and relative survival, of hatchery-origin and natural-origin Chinook salmon in the Dungeness River watershed to further scientific understanding of the genetic diversity and fitness effects of artificial propagation of the species, particularly effects resulting from hatchery subyearling Chinook salmon production.

2.11. Re-initiation of Consultation

This concludes formal consultation on the NMFS determination on, and BIA funding of, three salmon hatchery programs in the Dungeness River watershed.

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

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

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

This analysis is based, in part, on the descriptions of EFH for Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce. The Proposed Action includes an increase of the coho program by 300,000, in addition to that discussed in the 2016 BiOp.

3.1. Essential Fish Habitat Affected by the Project

As described in the 2016 BiOp, the action area of the Proposed Action includes habitat described as EFH for Chinook, coho, and pink salmon, groundfish, and coastal pelagic species.

Marine EFH for Chinook, coho, and Puget Sound pink salmon in Washington, Oregon, and California includes all estuarine, nearshore and marine waters within the western boundary of the EEZ, 200 miles offshore. Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable manmade barriers, and long-standing, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years). As described by PFMC (2014), within these areas, freshwater EFH for Pacific salmon consists of four major components: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat. Marine EFH for Chinook and coho salmon consists of three components: (1) estuarine rearing; (2) ocean rearing; and (3) juvenile and adult migration.

As further 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. HAPC 1 and 3 are potentially affected by the Proposed Action.

EFH for groundfish includes all waters, substrates, and associated biological communities from the mean higher high water line, or the upriver extent of saltwater intrusion in river mouths, seaward to the 3500 meters in depth contour plus specified areas of interest such as seamounts. A more detailed description and identification of EFH for groundfish is found in the Appendix B of Amendment 25 to the Pacific Coast Groundfish Management Plan (PFMC 2016b).

EFH for coastal pelagic species includes all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10°C to 26°C. A more detailed description and identification of EFH for coastal pelagic species is found in Amendment 15 to the Coastal Pelagic Species Fishery Management Plan (PFMC 2016a).

3.2. Adverse Effects on Essential Fish Habitat

The biological opinion describes in considerable detail the impacts hatchery programs might have on natural-origin salmon and steelhead populations (Section 2.5.2). The increased coho program may additionally contribute to redd superimposition than that described in the 2016 BiOp (Section 2.5.2), potentially affecting natural-origin salmon EFH. However, majority of salmon produced through the programs will be harvested in pre-terminal and terminal area fisheries, reducing the number of salmon that would escape to spawn in freshwater EFH. A substantial proportion of hatchery-produced salmon escaping terminal area fisheries home to their hatchery releases sites, further reducing the number of hatchery salmon that escape into natural spawning areas that are part of EFH in the basin.

The release of salmon through the additional coho production may lead to additional effects on EFH through predation on and competition with juvenile Chinook, coho, and pink salmon than that analyzed in the 2016 BiOp, though the level of predation and competition are minimized through release strategies and best management practice. Predation on and competition with natural-origin salmon in the marine environment is possible, but is likely limited by the release of hatchery fish that are ready to emigrate to the ocean quickly and the lack of a usable estuary for rearing outside of the Dungeness River.

The hatchery facility operation will continue to be the same as that described in the 2016 BiOp and are not expected to be affected by the operation of the hatchery programs, as no modifications to these areas would occur as part of this proposed action. While water intake structures in Dungeness River and Hurd Creek does not meet the NMFS intake screening nor fish passage criteria, we expect the effects to be minimal (see Section 2.5.2.5).

As described in the 2016 BiOp, the hatchery programs are not likely to have adverse effects on EFH for the coastal pelagic species and for groundfish because all relevant facilities have NPDES permits to minimize effects of organic waste, and antibiotics would be diluted to manufacturer labeling, in addition to minimizing effects on water quality. With the increased coho production, these potential adverse effects will remain minimal (see Section 2.5.2.5).

In summary, the proposed action is expected to have adverse effects on EFH for Chinook, coho, and pink salmon, but not for coastal pelagic species and groundfish.

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, NMFS believes that the Proposed Action, as described in the HGMPs and the ITS (Section 2.9), includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS associated with ecological interactions (i.e., spawning ground competition, redd superimposition, juvenile competition, and predation) constitute NMFS recommendations to address potential EFH effects. 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. Therefore, we ask that, in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5. Supplemental Consultation

The Federal action agencies must reinitiate EFH consultation with NMFS if the Proposed Action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR 600.920(l)).

4. Data Quality Act Documentation and Pre-Dissemination Review

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

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. NMFS has determined, through this ESA section 7 consultation, that operation of the three Dungeness River Hatchery programs as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an ITS. The intended users of this opinion are: the NMFS (permitting entity), the WDFW and the Jamestown S'Klallam Tribe (operating entities), and the BIA (funding entity). The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of Chinook salmon to the Dungeness River for conservation and harvest and coho and pink salmon to the Dungeness River for harvest, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of ESA-listed salmonids. This information will improve scientific understanding of hatchery-origin steelhead effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations. The document will be available within two weeks after signature at the NOAA Library Institutional Repository by visiting https://repository.library.noaa.gov/welcome or directly at https://doi.org/10.25923/anj3-vz06. 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[12] for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock[13]. 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.

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[12] The term "local fish" is defined to mean fish with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU or steelhead DPS (70 FR 37215, June 28, 2005).
[13] Exceptions include restoring extirpated populations and gene banks.

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 3. 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 limiting population growth (i.e., productivity) (NMFS 2004c).	**Negligible to negative effect** Productivity is dependent on differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).
Diversity	**Positive to negative effect** Hatcheries can temporarily support natural populations that might otherwise be extirpated or suffer severe bottlenecks and have the potential to increase the effective size of small natural populations. On the other hand, broodstock collection that homogenizes population structure is a threat to population diversity.	**Negligible to negative effect** Diversity is dependent on the differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat) and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).
Abundance	**Positive to negative effect** Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance of the natural populations in the ESU (70 FR 37204, June 28, 2005, at 37215). Increased abundance can also increase density dependent effects.	**Negligible to negative effect** Abundance is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect), handling, RM&E, and facility operation, maintenance and construction effects.
Spatial Structure	**Positive to negative effect** Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. "Any benefits to spatial structure over the long term depend on the degree to which the hatchery stock(s) add to (rather than replace) natural populations" (70 FR 37204, June 28, 2005 at 37213).	**Negligible to negative effect** Spatial structure is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).

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

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

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

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

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

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

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

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

5.2.1. Genetic effects

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

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

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

Inbreeding depression, another N_e-related phenomenon, is caused by the mating of closely related individuals (e.g., siblings, half-siblings, cousins). The smaller the population, the more likely spawners will be related. Related individuals are likely to contain similar genetic material, and the resulting offspring may then have reduced survival because they are less variable genetically or have double doses of deleterious mutations. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.

Outbreeding effects, the second major area of genetic effects of hatchery programs, are caused by gene flow from other populations. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993; Quinn 1997). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources. Hatchery programs can result in straying outside natural patterns for two reasons. First, hatchery fish may exhibit reduced homing fidelity relative to natural-origin fish (Goodman 2005; Grant 1997; Jonsson et al. 2003; Quinn 1997), resulting in unnatural levels of gene flow into recipient populations, either in terms of sources or rates. Second, even if hatchery fish home at the same level of fidelity as natural-origin fish, their higher abundance can cause unnatural straying levels into recipient populations. One goal for hatchery programs should be to ensure that hatchery practices do not lead to higher rates of genetic exchange with fish from natural populations than would occur naturally (Ryman 1991). Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997).

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

The proportion of hatchery fish (pHOS)[14] 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

[14] It is important to reiterate that as NMFS analyzes them, outbreeding effects are a risk only when the hatchery fish are from a different population than the naturally produced fish. If they are from the same population, then the risk is from hatchery-influenced selection.

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

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

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

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

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery- and natural-origin fish (e.g., e.g., Berntson et al. 2011; Ford et al. 2012; Hess et al. 2012; Theriault et al. 2011). All have shown that, generally, hatchery-origin fish have lower reproductive success; however, the differences have not always been statistically significant and, in some years in some studies, the opposite was true. Lowered reproductive success of hatchery-origin fish in these studies is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection, studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date, only the Hood River steelhead (Araki et al. 2007; Christie et al. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported multiple-generation effects.

Critical information for analysis of hatchery-induced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish[15]. 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 1).

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)[16]. PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. When the underlying natural population is of high conservation importance, the guidelines are a pHOS of no greater than 5 percent for isolated programs. For integrated programs, the guidelines are a pHOS no greater than 30 percent and PNI of at least 67 percent for integrated programs (HSRG 2009). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk in the short-term. (HSRG 2004)offered additional guidance regarding isolated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. The HSRG recently produced an update report (HSRG 2014) that stated that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

[15] 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.

[16] 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.

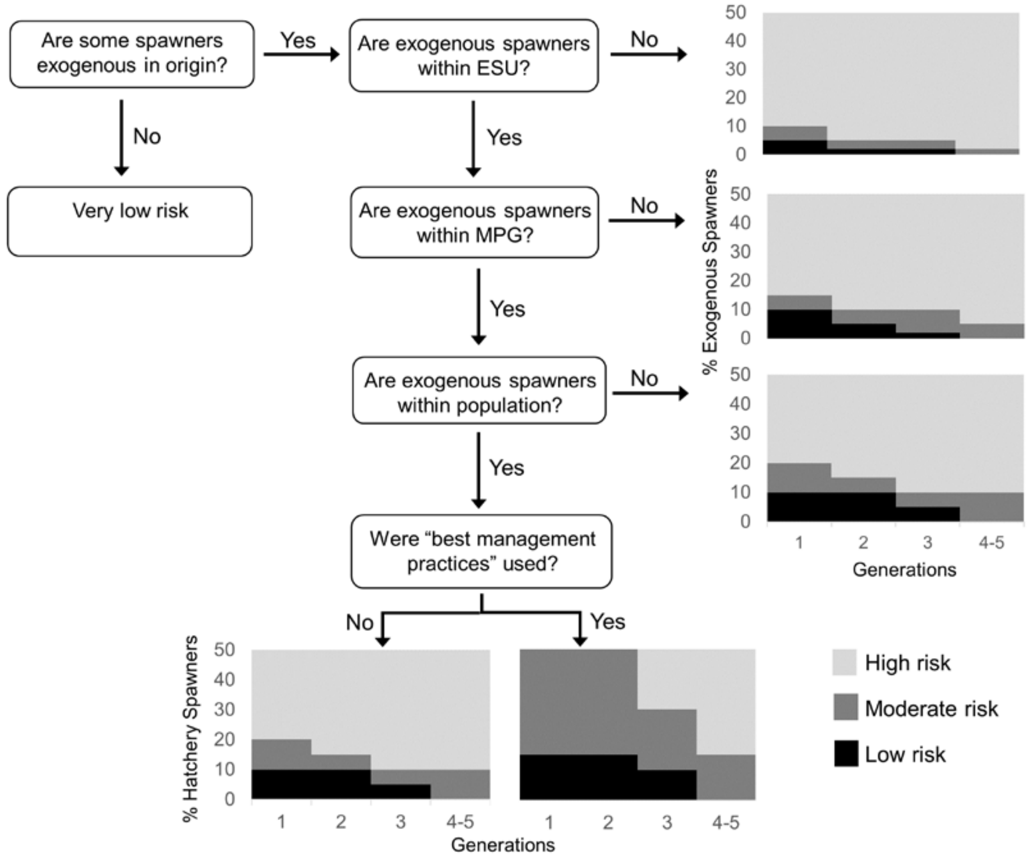

Figure 1. ICTRT (2007b) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish of hatchery origin, and non-normative strays of natural origin.

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* ($pHOS_{eff)}$ defined as the effective proportion of hatchery fish in the naturally spawning population. This confusion was cleared up in the 2014 update document, where it is clearly stated that the metric of interest is effective pHOS (HSRG 2014).

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

$$pHOS_{eff} = RRS * pHOS_{census}$$

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

$$PNI = \frac{pNOB}{(pNOB + pHOS_{eff})}$$

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

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

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

Additional perspective on pHOS that is independent of HSRG modelling is provided by a simple analysis of the expected proportions of mating types. Figure 2 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[17]. For example, at a census pHOS level of 10 percent, 81 percent of the matings will be NxN, 18 percent will be NxH, and 1 percent will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10 percent will have an 81 percent chance of having two natural-origin parents, etc.

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

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

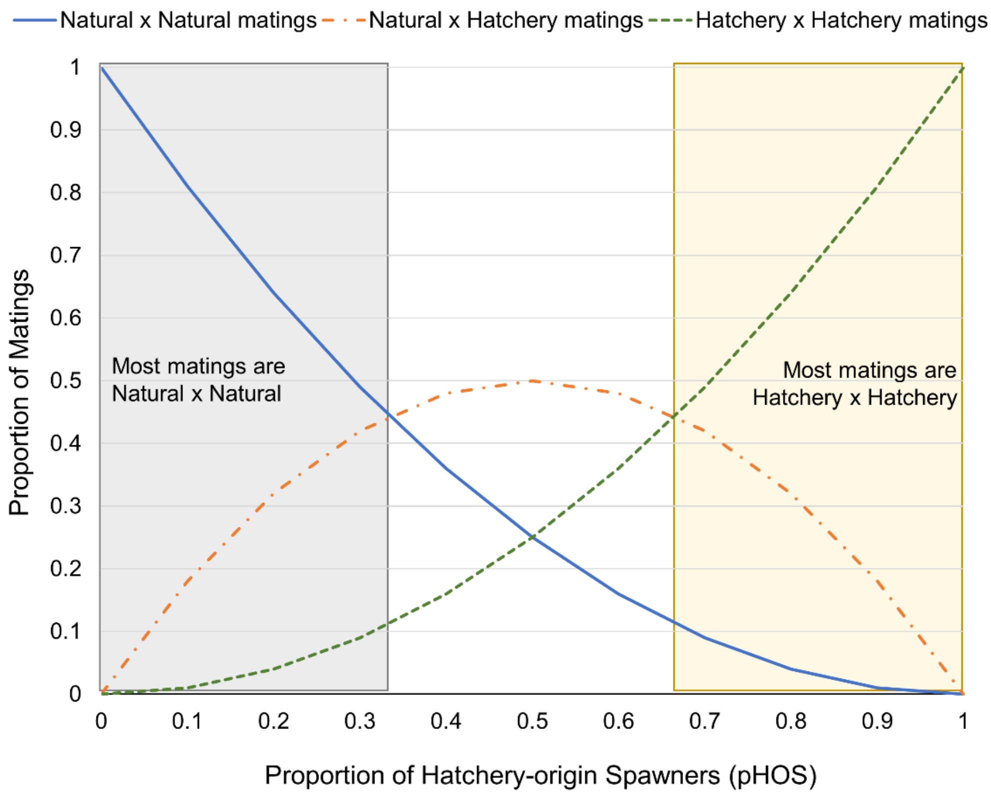

Figure 2. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS).

5.2.2. Ecological effects

Ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refer to effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects on the spawning grounds may be positive or negative. To the extent that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Gresh et al. 2000; Kline et al. 1990; Larkin and Slaney 1996; Murota 2003; Piorkowski 1995; Quamme and Slaney 2003; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase (Bell 2001; Bilton et al. 1982; Bradford et al. 2000; Brakensiek 2002; Hager and Noble 1976; Hartman and Scrivener 1990; Holtby 1988; Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Ward and Slaney 1988).

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

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

5.2.3. Adult Collection Facilities

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

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

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

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

5.3.1. Competition

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

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

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

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

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

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

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

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (California HSRG 2012; Steward and Bjornn 1990)

- Operating hatcheries such that hatchery fish are reared to a size sufficient to ensure that smoltification occurs in nearly the entire population

- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing by naturally produced juveniles

- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and release timing if substantial competition with naturally rearing juveniles is determined likely

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[18] 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

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

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

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

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

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

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

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.

- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.

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

5.3.3. Disease

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

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

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

The transmission of pathogens between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Naish et al. 2008; Steward and Bjornn 1990). This lack of reporting is because both hatchery and natural-origin salmon and trout are susceptible to the same pathogens (Noakes et al. 2000), which are often endemic and ubiquitous (e.g., *Renibacterium salmoninarum*, the cause of Bacterial Kidney Disease).

Adherence to a number of state, federal, and tribal fish health policies limits the disease risks associated with hatchery programs (IHOT 1995; NWIFC and WDFW 2006; ODFW 2003; USFWS 2004). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*). If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

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

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

5.3.4. Acclimation

One factor 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 19^{th} century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2014).Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Dunnigan 1999; Quinn 1997; YKFP 2008).

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

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

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

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

NMFS also analyzes proposed RM&E for its effects on listed species and on designated critical habitat. The level of effect for this factor ranges from positive to negative.

Generally speaking, negative effects on the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces uncertainty. RM&E actions can cause harmful changes in behavior and reduced survival; such actions include, but are not limited to:

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

5.4.1. Observing/Harassing

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

5.4.2. Capturing/handling

Any physical handling or psychological disturbance is known to be stressful to fish (Sharpe et al. 1998). Primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and holding vessel), dissolved oxygen conditions, the amount of time fish are held out of the water, and physical trauma. Stress increases rapidly if the water temperature exceeds 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 2008b) that have been incorporated as terms and conditions into section 7 opinions and section 10 permits for research and enhancement. Additional monitoring principles for supplementation programs have been developed by the (Galbreath et al. 2008).

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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Appendix B – 2016 BiOp

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Conference Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation: National Marine Fisheries Service (NMFS) Evaluation of Three Hatchery and Genetic Management Plans for Dungeness River Basin Salmon under Limit 6 of the Endangered Species Act Section 4(d) Rule.

NMFS Consultation Number: NWR-2013-9701

Signed: May 31, 2016

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

National Marine Fisheries Service (NMFS) Evaluation of Three Hatchery and Genetic Management Plans for Dungeness River Basin Salmon under Limit 6 of the Endangered Species Act Section 4(d) Rule

NMFS Consultation Number: NWR-2013-9701

Action Agencies: National Marine Fisheries Service and Bureau of Indian Affairs

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?**
Puget Sound steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	No
Puget Sound Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No

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

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

Issued By: for William W. Stelle, Jr.
Regional Administrator

Date: ______May 31, 2016________

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Table of Contents

Figures

Tables

1. INTRODUCTION

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

The two components of the proposed action are:

(1) the National Marine Fisheries Service's (NMFS) determination under limit 6 of the ESA 4(d) rule for listed Puget Sound Chinook salmon and listed Puget Sound steelhead (50 CFR § 223.203(b)(6)) concerning three hatchery programs in the Dungeness Basin submitted for review by the Washington Department of Fish and Wildlife (WDFW), with the Jamestown S'Klallam Tribe as the *U.S. v. Washington* fish resource co-manager; and,
(2) the Bureau of Indian Affairs' (BIA) ongoing disbursement of funds to the Jamestown S'Klallam Tribe for operation and maintenance of the Dungeness River Hatchery programs listed in Table 1.

Collectively, NMFS and the BIA are the "Action Agencies." Pursuant to the October 24, 2013, letter received by NMFS from the BIA, NMFS is the designated lead agency for the conduct of this consultation (Speaks 2013).

The WDFW and Jamestown S'Klallam Tribe propose to operate three hatchery programs that release Chinook, coho and pink salmon into the Dungeness Basin (Table 1). Coho and pink salmon produced from these programs are not listed under the Endangered Species Act (ESA), but the Chinook salmon are listed. The hatchery programs are operated to conserve at-risk native salmon populations (Chinook and pink salmon) and partially mitigate for lost natural-origin fish production largely resulting from past and on-going loss and degradation of natural fish habitat, and impending climate change. The coho salmon program currently helps meet tribal fishery harvest allocations that are guaranteed through treaties, as affirmed in *U.S. v. Washington* (1974). Program-origin Chinook and coho salmon also help meet Pacific Salmon Treaty harvest sharing agreements with Canada.

Table 1. Programs associated with the proposed actions, including program operator and funding agency.

Hatchery and Genetics Management Plan	Program Operator	Funding Agency
Dungeness River Hatchery Spring Chinook (Integrated)	WDFW	WDFW, BIA
Dungeness River Hatchery Pink (Fall-Run) Salmon (Integrated)	WDFW	WDFW
Dungeness River Coho Hatchery Program (Segregated)	WDFW	WDFW, BIA

1.1. Background

NMFS prepared the biological opinion (opinion), conference opinion, and incidental take statement 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 and the BIA.

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

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

1.2. Consultation History

The HGMPs considered here are part of a more comprehensive recent history of hatchery program development in Puget Sound. The first hatchery consultations in Puget Sound followed the listing of the Puget Sound Chinook Evolutionarily Significant Unit (ESU) under the ESA (64 FR 14308, March 24, 1999). In 2005, WDFW and the Puget Sound tribes ("co-managers") completed two resource management plans (RMP-PSTT and WDFW 2004; WDFW and PSIT 2004) as the overarching frameworks for 114 HGMPs, including HGMPs for the Dungeness hatchery programs. The HGMPs described how each hatchery program would operate, including effects on listed fish in the Puget Sound region. In 2004, the co-managers submitted the two RMPs and 114 HGMPs to NMFS for ESA review under limit 6 of the ESA 4(d) rule (50 C.F.R. 223.203). Of the 114 HGMPs, 75 were state operated including 27 Chinook salmon programs, 22 coho salmon programs, 2 plans for pink salmon, 4 plans for chum salmon, 2 plans for sockeye salmon, and 18 HGMPs for steelhead. The Puget Sound Tribes submitted 38 HGMPs, including 14 programs for Chinook salmon, 13 for coho salmon, 9 for fall chum salmon, and 2 for steelhead. United States Fish and Wildlife Service (USFWS) submitted 1 HGMP for its coho salmon program at Quilcene National Fish Hatchery.

Subsequent to the submittal of the plans to NMFS, the Puget Sound steelhead Distinct Population Segment (DPS) was listed as "threatened" (72 FR 26722, May 11, 2007). On September 25, 2008, NMFS issued a final 4(d) rule adopting protective regulations for the listed Puget Sound steelhead DPS (73 FR 55451). In the final rule, NMFS applied the same 4(d) protections to steelhead as were already adopted for other ESA-listed Pacific salmonids in the region. Accordingly, the co-manager hatchery plans are now also subject to review for effects on listed steelhead.

Separately from the proposed action reviewed in this opinion, two resource management plans, encompassing all 114 Puget Sound region HGMPs, were submitted by the co-managers for review by NMFS, leading to determinations of whether the plans address criteria defined in the ESA 4(d) Rule Limit 6 for the Puget Sound Chinook Salmon ESU, (where applicable) the Hood Canal Summer Chum Salmon ESU [see 65 FR 42422 (July 10, 2000), as amended 70 FR 37160 (June 28, 2005)], and in the 4(d) Rule for the Puget Sound Steelhead DPS [73 FR 55451 (September 25, 2008)].

For HGMPs determined through NMFS review to satisfy the 4(d) Rule criteria, ESA section 9 take prohibitions will not apply to hatchery activities managed in accordance with the plans. To meet NEPA requirements associated with NMFS's eventual 4(d) determinations on these 114 programs encompassing the entire Puget Sound region, a Draft Environmental Impact Statement (Draft EIS) was prepared, to disclose to the public the likely environmental effects of the proposed hatchery programs, and of alternative hatchery production scenarios under the programs (NMFS 2014a). The Draft EIS was released for public review and comment in the summer of 2014. Over the term of NMFS's preparation of the Draft EIS, the Puget Sound co-managers made important changes in hatchery programs for salmon and steelhead, leading to revisions in the hatchery plans reviewed in the Draft EIS. Included in the revised hatchery plans, which were generally organized and submitted for review on a watershed basis, was updated information important for analysis of their effects at the individual program and watershed scale. These updated, watershed-specific hatchery plans are being submitted to NMFS to replace the 114 HGMPs included in the co-manager resource management plans reviewed in the Draft EIS. Considering on-going submissions of revised hatchery plans, and public comments on the Draft EIS, NMFS determined that the EIS would be withdrawn and replaced with NEPA reviews of updated replacement RMPs, generally organized on a watershed basis (80 FR 15986, March 26, 2015). Information in the withdrawn EIS, along with public comments received on the Draft EIS, will be considered by NMFS in subsequent NEPA reviews of watershed-specific hatchery plans. Similarly, NMFS will conduct ESA reviews of hatchery program effects on listed fish species on a watershed-specific basis as those plans are received in updated form. Under this watershed-scale approach, NMFS will evaluate the effects of hatchery programs that are unique to each watershed, including whether the programs address ESA 4(d) rule criteria for hatchery actions, or warrant coverage under ESA section 10 or 7, as appropriate.

Among the 114 HGMPs were draft plans developed by WDFW with the support of the Jamestown S'Klallam Tribe describing proposed hatchery programs for Chinook salmon, coho salmon, and pink salmon in the Dungeness River Basin. The three Dungeness River salmon HGMPs were subsequently updated by WDFW and the Jamestown S'Klallam Tribe from the plans reviewed in the withdrawn EIS. On January 18, 2013, the three salmon HGMPs for WDFW's Dungeness River Hatchery were submitted to NMFS as final co-manager-agreed plans specific for the Dungeness River watershed (Scott 2013). WDFW and the Jamestown S'Klallam Tribe requested processing of the three HGMPs under limit 6 of the 4(d) rule (Missildine 2013). After reviewing the plans, NMFS determined that they included information sufficient[1] for the agency to complete its determination of whether the HGMPs addressed criteria specified in the ESA 4(d) Rule Limit 6 for the Puget Sound Chinook Salmon ESU and in the 4(d) Rule for the Puget Sound Steelhead DPS [73 FR 55451 (September 25, 2008)]. Consultation was initiated on July 30, 2013. Subsequently, in an October 24, 2013, letter, the BIA requested initiation of formal consultation on their action of funding the hatchery programs (Speaks 2013); in response, NMFS included the BIA proposed funding action into the consultation on the hatchery programs themselves. NMFS is the designated lead agency for the conduct of this consultation (NMFS 2013c).

This consultation evaluates effects of the proposed action on ESA-listed Puget Sound Chinook salmon and Puget Sound steelhead and their critical habitat, as described in more detail in Section 2.2 and Table 2. The effects associated with implementation of Dungeness River Hatchery salmon production on the Hood Canal Summer Chum Salmon ESU were previously evaluated by NMFS when consulting pursuant to ESA section 7 on the eight programs rearing summer chum salmon (NMFS 2002). In that

[1] "Sufficient" means that an HGMP meets the criteria listed at 50 CFR 223.203(b)(5)(i), which include (1) the purpose of the hatchery program is described in meaningful and measureable terms, (2) available scientific and commercial information and data are included, (3) the Proposed Action, including any research, monitoring, and evaluation, is clearly described both spatially and temporally, (4) application materials provide an analysis of effects on ESA-listed species, and (5) preliminary review suggests that the program has addressed criteria for issuance of ESA authorization such that public review of the application materials would be meaningful. However, it does not prejudge the outcome of NMFS' review to determine whether the program meets the standard for an exemption from the ESA's §9 prohibitions.

consultation, NMFS determined that the effects of other hatchery programs, including the currently proposed programs in the Dungeness River, had minimal likelihood of adverse effects on Hood Canal summer chum salmon. The hatchery actions proposed in the 2013 HGMPs are substantively the same as the actions evaluated and authorized in the previous NMFS biological opinion. The previous evaluation and authorization of Dungeness River Hatchery plan effects on Hood Canal summer chum salmon therefore remain valid. For these reasons, effects on Hood Canal summer chum salmon associated with the proposed salmon HGMPs will not be discussed further in this biological opinion.

This biological opinion is based on information provided in the three Dungeness River Hatchery salmon HGMPs.

1.3. Proposed Action

"Action" means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies.

The two components of the proposed action are:

(1) the National Marine Fisheries Service's (NMFS) determination under limit 6 of the ESA 4(d) rule for listed Puget Sound Chinook salmon and listed Puget Sound steelhead (50 CFR § 223.203(b)(6)) concerning three hatchery programs in the Dungeness River watershed submitted for review by the Washington Department of Fish and Wildlife (WDFW), with the Jamestown S'Klallam Tribe as the *U.S. v. Washington* fish resource co-manager; and,

(2) the Bureau of Indian Affairs' (BIA) dispersal of funds to the Jamestown S'Klallam Tribe in support of their exercise of off-reservation treaty rights, which the Tribe uses, in part, to support the operation of the Dungeness River Hatchery programs listed in Table 1.

NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008c). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004). In this specific case, the proposed hatchery programs described in the January 18, 2013, HGMPs (WDFW 2013a; WDFW 2013b; WDFW 2013c) were determined sufficient for formal consultation (Jones 2013; WDFW 2013a; WDFW 2013b; WDFW 2013c). One of the hatchery programs releases ESA-listed Chinook salmon (WDFW 2013a), and two hatchery programs release non-ESA listed pink (WDFW 2013b) and coho salmon (WDFW 2013c) into the Dungeness River watershed. All of the programs are currently operating, and all three salmon hatchery programs raise fish native to the Dungeness River.

The hatchery programs are designed to help meet fish loss mitigation responsibilities, partially off-setting adverse impacts on natural-origin salmon and their habitat resulting from past and on-going human developmental activities in the Dungeness River basin and from climate change. The spring Chinook and pink salmon programs produce adult fish from the at-risk native stocks for conservation purposes, with the goal of restoring healthy, naturally spawning, self-sustaining populations of the species in the Dungeness River watershed. All of the programs also implement salmon population monitoring activities in marine and fresh waters that are important for tracking the status of listed fish populations and the effects of the hatchery programs.

1.3.1. Describing the Proposed Action

As described in section 1.8 of the Hatchery and Genetics Management Plans (HGMP) (WDFW 2013a; WDFW 2013b; WDFW 2013c), the Chinook and pink hatchery programs are integrated[2] programs intended to provide conservation benefits. Fish produced from these programs are intended to spawn in the wild and to fully integrate reproductively with the natural Chinook and pink salmon populations. The coho salmon program is intended to function for segregated/isolated[2] purposes to provide harvest benefits. Dungeness River Hatchery-origin coho salmon are not intended to spawn naturally and are not intended to establish, supplement, or support any coho salmon populations occurring in the natural environment. All of the programs are currently operating. All three hatchery programs propagate the extant salmon stocks native to the Dungeness River.

Facilities associated with the proposed action are:

- Dungeness River Hatchery (RM 10.5 on the Dungeness River)
- Hurd Creek Hatchery (RM 0.2 on Hurd Creek, tributary to the Dungeness River at RM 2.7)
- Mainstem Dungeness River weir (RM 2.5 on the Dungeness River)
- Gray Wolf Acclimation Pond (RM 1.0 on the Gray Wolf River, tributary to the Dungeness River at RM 15.8)
- Upper Dungeness Acclimation Site (RM 15.8 on the Dungeness River)
- Cooper Creek (local name; unnamed tributary [WRIA 18.0017] to the Strait of Juan de Fuca 1.6 miles east of the Dungeness River mouth)

In addition, adult salmon would be collected for use as broodstock in the lower Dungeness River, downstream of Dungeness River Hatchery, through opportunistic seining, gaffing, dip-netting, or hook-and-line collection. Monitoring and evaluation activities would occur at the hatcheries and in their immediate vicinities in Hurd Creek, Gray Wolf River, and in the Dungeness River extending from the mouth of the Dungeness River upstream to the limits of anadromous fish access (impassable falls at RM 18.7 [Haring 1999]).

Activities included in the plans are as follows:

- Broodstock collection at WDFW's Dungeness River Hatchery through operation of weirs, fish traps, hatchery collection ponds, and by various other methods in the lower 3.5 miles of the Dungeness River;
- Transport of Chinook salmon broodstock from Dungeness River Hatchery to Hurd Creek Hatchery;
- Holding, identification, and spawning of adult fish at Dungeness River Hatchery, Hurd Creek Hatchery, or on-site at the point of pink salmon capture in the lower Dungeness River collection location;
- Egg incubation at Dungeness River Hatchery and Hurd Creek Hatchery and fish rearing at Dungeness River Hatchery, Hurd Creek Hatchery, Gray Wolf Acclimation Pond, and the Upper Dungeness Acclimation Site;
- Release of up to: 200,000 juvenile Chinook salmon (e.g., 150,000 subyearling and 50,000 yearlings) from Dungeness River Hatchery, Hurd Creek Hatchery, Gray Wolf Acclimation Pond,

[2] These terms are defined in Section 2.4.1.

and the Upper Dungeness Acclimation Site; 500,000 yearling coho salmon from Dungeness River Hatchery; 2,000 coho salmon fry transferred and planted into Cooper Creek by local schools; and 100,000 pink salmon fry released from Hurd Creek Hatchery;

- Monitoring and evaluation activities to assess the performance of the programs in meeting conservation, harvest augmentation, and listed fish risk minimization objectives.

1.3.1.1. Proposed hatchery broodstock collection

- Broodstock origin and number: Up to 112 Chinook salmon adults, 110 fall-run pink salmon adults, and 500 coho salmon adults will be collected from returns to the Dungeness River for use as hatchery broodstock each year. These numerical collection objectives assume a 50-50 sex ratio in annual collections of each species.
- Proportion of natural-origin fish in the broodstock (pNOB): The proposed action does not include specifically targeting natural- or hatchery-origin adults in broodstock collection, therefore the proportion of natural-origin fish collected as broodstock will be approximately equivalent to the proportion present in the total annual return of Dungeness Chinook salmon to the lower Dungeness River where broodstock collection occurs. For the two years (2010 and 2011) for which data are available – years when the program relied on broodstock collected from the river rather than from fish originating from a now-terminated captive broodstock program (Marlowe et al. 2001) – 21.6% of the adult fish collected were natural-origin Chinook salmon. All hatchery-origin Chinook salmon are identified by presence of a coded-wire tag (CWT).
- Broodstock selection: A representative sample from throughout the total adult Chinook salmon return will be collected for use as broodstock.
- Method and location for collecting broodstock: Chinook and coho salmon broodstock will be collected as volunteers to the Dungeness River Hatchery trap through the facility's ladder. Chinook salmon adults will also be collected at the mainstem weir and trap at river mile (RM) 2.5 continuously attended by on-site staff, and through opportunistic gillnetting and gaffing operations in the lower river. Pink salmon adults are collected in the lower 3.5 miles of the Dungeness River using the mainstem river weir and trap, and through opportunistic seining, gaffing, and dip-netting. Other methods (e.g., noodling (capture by hand) or snagging) may also be used to collect broodstock.
- Duration of collection: Dungeness River Hatchery will operate its fish ladder and trap from mid-May through February to collect Chinook and coho salmon as broodstock. The mainstem weir is operated to collect Chinook salmon from May (if feasible given flow levels) through the end of September. Collection of Chinook and pink salmon broodstock in the lower river occurs from July through September.
- Encounters during sorting and handling with ESA-listed fish, adults and juveniles: ESA-listed natural- and hatchery-origin Chinook salmon will be collected for use as broodstock to meet goal egg take levels at proportions of the total adult return equivalent to the run at large each year. Adults collected surplus to broodstock needs will be returned to the river upstream to spawn naturally. ESA-listed steelhead are not expected to be encountered, as they are unlikely to volunteer to Dungeness River Hatchery trap – the only broodstock collection location operating during the adult steelhead migration period. Listed juvenile Chinook salmon and steelhead are unlikely to be encountered and handled through the methods used to collect salmon broodstock, and at the time broodstock collection facilities are operated.

1.3.1.2. Proposed mating protocols (ESA-listed Chinook salmon only)

- All available mature Chinook salmon collected from returns to the river are used for spawning.
- Adults held as broodstock are chosen at random for spawning, without consideration for age or size. The program goal is to conduct matings at a 1:1 sex ratio whenever possible.
- Factorial 2x2 crosses are the preferred method used for mating, but if necessary, other combinations would be applied to maximize genotypic diversity. In 2x2 crosses, eggs from two females would be split into two separate containers per female, and milt from two males would be split into two separate containers per male. Eggs and milt would then be mixed in all possible pairwise combinations.

1.3.1.3. Proposed protocols for each release group

- Life stage: Chinook salmon: Subyearlings at 50 fish per pound (fpp) and yearlings at 9 fpp. Coho salmon: Yearlings at 17 fpp and fry at 200 fpp. Pink salmon: Fry at 450 fpp.
- Acclimation (Y/N): Yes. Chinook salmon at Dungeness River Hatchery, Hurd Creek Hatchery, Gray Wolf Acclimation Pond, and Upper Dungeness Acclimation Pond. All yearling coho salmon and pink salmon fry would be acclimated at Dungeness River Hatchery.
- Volitional release (Y/N): Chinook salmon: Yes. Coho salmon yearlings: Yes. Pink salmon: No.
- External mark(s): All Chinook salmon are released without an external mark because they are produced for population recovery purposes. All coho salmon yearlings are marked with an adipose fin clip; fry are unmarked. All pink salmon fry are marked with an adipose fin clip.
- Internal marks/tags: All Chinook salmon are marked with a CWT (whose tag numbers are sufficient to identify release strategy and location). Coho and pink salmon are released without any internal marks or tags.
- Maximum number released: Maximum annual production will be 150,000 subyearling and 50,000 yearling Chinook salmon; 500,000 coho salmon yearlings and 2,000 coho salmon fry; and 100,000 pink salmon fry.
- Release location(s): Chinook subyearlings: Dungeness River Hatchery (RM 10.5 on the Dungeness River); Gray Wolf Acclimation Pond (RM 1.0 on the Gray Wolf River, tributary to the Dungeness River at RM 15.8); and Upper Dungeness Acclimation Site (RM 15.8 on the Dungeness River). Chinook yearlings: Hurd Creek Hatchery (RM 0.2 on Hurd Creek, tributary to the Dungeness River at RM 2.7; Coho salmon yearlings and pink salmon fry: Dungeness River Hatchery (RM 10.5 on the Dungeness River); Coho salmon fry: Cooper Creek (RM 0.1 on Cooper Creek, tributary to the Strait of Juan de Fuca, 1.2 miles east of the Dungeness River mouth).
- Time of release: Chinook salmon subyearlings in June; yearlings in April. Coho salmon: Yearlings and fry in May-June. Pink salmon fry: April/May.
- Fish health certification: Reporting and control of specific fish pathogens will be conducted in accordance with the Co-Managers of Washington Fish Health Policy.

1.3.1.4. Proposed adult management (listed Chinook salmon)

- Anticipated number or range in hatchery fish returns originating from this program: Assuming smolt to adult return rates of 0.5% for subyearlings and 1.0% for yearlings (WDFW hatchery goal levels from Fuss and Ashbrook, 1995), the proposed Dungeness River Hatchery Spring Chinook program may produce 1,250 adults (total survival to fisheries and escapement). The program is operated as a conservation program for native stock population recovery purposes. Natural spawning by hatchery-origin fish is an intent of the program, given the critically depressed status of the native, natural-origin component of the population. Recent, post-captive brood program data (2005 - 2013) indicate that an annual average of 64% of naturally spawning fish are first generation hatchery-origin Chinook salmon.
- Removal of hatchery-origin fish and the anticipated number of natural-origin fish encountered: Annual broodstock collection will lead to the removal from the river of up to 112 adults, and unintentional mortality of up to 18 adults resulting from collection actions applied. Of this total, approximately 36% may be natural-origin Chinook salmon, assuming continuation of recent year hatchery- and natural-origin fish contribution levels to the total escapement.
- Appropriate uses for hatchery fish that are removed: Hatchery broodstock, human consumption (e.g., food banks), and in-stream marine-derived nutrient enhancement.
- Are hatchery fish intended to spawn naturally (Y/N): Yes
- Performance standard for pHOS (proportion of naturally spawning fish that are of hatchery-origin): There is no pHOS standard proposed for the Chinook salmon program.
- Performance standard for stray rates into natural spawning areas: Hatchery-origin fish are intended to spawn naturally and there is no stray rate standard proposed for this program.

1.3.1.5. Proposed research, monitoring, and evaluation

- Adult sampling, purpose, methodology, location, and the number of ESA-listed fish handled: All juvenile Chinook salmon produced through the Dungeness River Chinook Hatchery program are identified with distinct otolith marks, CWT, or blank wire tags to allow for evaluation of program performance and effects on listed Chinook salmon. WDFW will monitor Chinook, coho, and pink salmon escapement to the Dungeness River to estimate the number of tagged, untagged, and adipose fin clipped adult fish escaping to the river each year. This monitoring will allow for assessment of the status of the target populations for recovery, and the success of the programs in achieving restoration (Chinook and pink salmon) or harvest augmentation (coho salmon) objectives.

- Juvenile sampling, purpose, methodology, location, and the number of ESA-listed fish handled: WDFW's Wild Salmon Production Evaluation Unit operates a juvenile salmonid out-migrant trap in the mainstem Dungeness River (RM 0.5) to estimate wild juvenile salmonid production. The effects of the juvenile out-migrant trapping program on listed salmon have been reviewed and authorized through a separate ESA consultation.

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

- Water source(s) and quantity for hatchery facilities: Four hatchery facilities are operated to support the three proposed salmon hatchery programs. The Dungeness River Hatchery facility uses surface water exclusively, withdrawn through three water intakes on the Dungeness River and one on Canyon Creek, an adjacent tributary. The Hurd Creek Hatchery facility uses a combination of groundwater withdrawn from five wells, and surface water withdrawn from Hurd Creek for fish rearing and as an emergency back-up source. The Gray Wolf Acclimation Pond is supplied with surface water that is gravity fed from the Gray Wolf River. The Upper Dungeness Acclimation Ponds are supplied with pumped surface water from the Dungeness River. Dungeness River Hatchery may withdraw up to 40 cfs of surface water from the Dungeness River and up to 8.5 cfs from Canyon Creek. Hurd Creek Hatchery may withdraw up to 1.4 cfs from Hurd Creek. Up to 1.0 cfs may be withdrawn from the Gray Wolf River for operation of the Gray Wolf Acclimation Pond program, and up to 1.0 cfs withdrawn from the Dungeness River for the Upper Dungeness Acclimation Pond program. Assuming hatchery water withdrawals at maximum permitted levels, up to 62 percent of the water during the lowest streamflow on record (65 cfs) or 50 percent of the 99 percent exceedance low flow (80 cfs) in the Dungeness River could be temporarily diverted into Dungeness River Hatchery to support the three salmon hatchery programs, and 13 percent of the water in the river could be withdrawn during median flows (299 cfs). The distance between the intake and discharge point for water used for fish rearing is 4,460 feet (unpublished data from D. Gombert, WDFW, pers. comm., December 19, 2013), so flow volumes in the Dungeness River over that distance could be affected. Under worst case circumstances, if water was withdrawn at the permitted maximum level during the summer-time low flow period, up to 100 percent of the water in Canyon Creek could potentially be temporarily diverted into Dungeness Hatchery for discharge into the Dungeness River at the hatchery outfall. Withdrawal under these worst case circumstances would potentially affecting flow volumes in lower Canyon Creek and a stretch of the Dungeness River adjacent to the hatchery, given the relative locations of the water withdrawal and discharge points (WDFW 2014). Up to 70 percent of the water in Hurd Creek could be withdrawn for emergency use only (if pumps for wells fail) for the Chinook and fall-run pink salmon rearing programs, potentially affecting 1,720 feet of the creek between the surface water intake and the hatchery discharge point (unpublished data from D. Gombert, WDFW, pers. comm., December 19, 2013). Up to 0.5 percent of the flow in the Gray Wolf River could be used for the Chinook salmon acclimation pond program on the tributary, affecting flows in no portion of the river because the water intake and discharge points are in the same location. The Upper Dungeness River Ponds program could potentially use a maximum of 0.3 percent of the surface water in the Dungeness River at the point of water withdrawal. Because the water intake and discharge points for the ponds are in the same location, flows in any portion of the river would be unaffected.

  Water withdrawals up to maximum levels would only occur during the spring months, when fish sizes and rearing water needs at the hatcheries are highest, and flows in surface waters are at seasonal maximums. The four hatchery facilities have current surface water right permits issued by WDOE authorizing water withdrawals up to the amounts identified as maximums. Surface water withdrawal rights are formalized through Washington State water right permits # S2-06221 (25 CFS) & S2-21709 (15 CFS) for the Dungeness River and # S2-00568 (8.5 CFS) for Canyon Creek. Hurd Creek Hatchery water rights are formalized through permit # G2-24026.

Monitoring and measurement of water usage are reported in monthly National Pollutant Discharge Elimination System (NPDES) reports to WDOE.

- Water diversions meet NMFS screen criteria (Y/N): No. The main water intake on the Dungeness River mainstem where most water is currently withdrawn for fish production at Dungeness River Hatchery is not screened to be in compliance with current NMFS fish passage guidelines (NMFS 1994)) to protect juvenile fishes. However, screening at this location is only out of compliance during high flow events. Screening for a siphon water intake upstream from the mainstem hatchery water intake is out of compliance with NMFS screening guidelines, as is the water intake structure on Canyon Creek where additional water for fish rearing may be withdrawn during the winter months. The surface water emergency backup intake screens for Hurd Creek Hatchery are in compliance with earlier federal guidelines (NMFS 1995, 1996), but do not meet criteria specified more recently by NMFS (2011b) (WDFW 2013a).

- Permanent or temporary barriers to juvenile or adult fish passage (Y/N): Yes. The Canyon Creek water intake supplying Dungeness River Hatchery is adjacent to a small dam that completely blocks access to upstream salmon spawning habitat. NMFS has completed informal consultation with the U.S. Army Corps of Engineers (Corps) on their issuance of a permit to the WDFW for construction of a vertical slot fish ladder in the diversion dam on Canyon Creek (NMFS 2013b), expected to be complete by fall 2017 (A. Carlson, WDFW, pers. comm., April 24, 2015). NMFS concluded that effects of the construction would not be likely to adversely affect ESA-listed species. When completed, the ladder will allow unimpeded upstream and downstream passage by migrating salmon and steelhead encountering the Canyon Creek diversion dam, and the water intake structure will be in compliance with NMFS (2011b) fish passage criteria. WDFW operates a temporary weir and trap on Dungeness River at RM 2.5 to collect Chinook salmon broodstock from May (if flows allow weir placement) through September. This temporary weir structure will be a barrier to upstream fish migration when in operation.

- Instream structures (Y/N): Yes. There are instream diversions associated with hatchery water intake structures at RM 10.5 in the Dungeness River, on Canyon Creek at RM 0.2, and on Hurd Creek at RM 2.7.

- Streambank armoring or alterations (Y/N): No. No new construction, armoring, or streambank alterations are proposed as part of the hatchery program actions. Minor armoring would be maintained at three locations, at the diversion structure, water return, and at the entrance to the fish ladder.

- Pollutant discharge and location(s): All Dungeness River Hatchery programs operate under National Pollutant Discharge Elimination System (NPDES) permit number WAG 13-1037. Under its NPDES permit, Dungeness River Hatchery operates an off-line settling pond and artificial wetland to remove effluent before the water is released back into the Dungeness River (WDFW 2013a). Although under the 20,000 pounds per year fish production criteria set by WDOE as the limit for concern regarding hatchery effluent discharge effects, at Hurd Creek Hatchery, WDFW has constructed a two-bay pollution abatement pond to treat water prior to its release into Hurd Creek. The fish rearing ponds on the Gray Wolf River and the Upper

Dungeness River also have low annual fish production levels, below those for which a NPDES permit is required.

1.3.2. Interrelated and Interdependent Actions

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration. In determining whether there are interrelated and interdependent actions that should be considered in this consultation, NMFS has considered whether fisheries impacting Dungeness River Hatchery program fish are interrelated or interdependent actions that are subject to analysis in this opinion.

Within the Dungeness River action area, recreational fisheries and tribal commercial and ceremonial and subsistence fisheries occur, targeting unlisted coho salmon produced by the proposed coho salmon hatchery program. These fisheries are managed by the Jamestown S'Klallam Tribe and WDFW, and occur within the Dungeness River and Dungeness Bay. The proposed Chinook and pink salmon conservation hatchery programs (WDFW 2013a; WDFW 2013b) and the coho salmon program (WDFW 2013c) analyzed in this opinion also contribute to regional fisheries outside of the Dungeness River watershed. Fisheries inside and outside of the action area support values associated with Treaty-reserved fishing rights recognized by the Federal courts, and help to meet Pacific Salmon Treaty harvest sharing agreements with Canada. The effects of all fisheries that incidentally harvest ESA-listed fish species originating from the Dungeness River, including fisheries within the action area directed at Dungeness River Hatchery coho salmon, have been evaluated through a separate NMFS ESA consultation (NMFS 2015b). After reviewing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, NMFS' concluded that proposed Puget Sound region harvest actions are not likely to jeopardize the continued existence of the Puget Sound Chinook Salmon ESU or the Puget Sound Steelhead DPS or adversely modify designated critical habitat for the two listed species (NMFS 2015b). For these reasons, fisheries inside and outside of the Dungeness River/Dungeness Bay action area are not interrelated and interdependent with respect to the proposed action, and their effects, along with the effects of past fisheries in the action area, are included in the Environmental Baseline.

1.4. 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 and not merely the immediate area involved in the action (50 CFR 402.02). The action area resulting from this analysis includes the Dungeness River watershed, its tributaries, and nearshore marine waters of Dungeness Bay (Figure 1), including all marine waters of the bay south and westerly of Dungeness Spit. These areas include the hatchery facilities and places where Dungeness River salmon are proposed to be collected as broodstock, spawned, incubated, reared, acclimated, and released.

NMFS also considered whether the marine areas of Puget Sound outside of Dungeness Bay and in the ocean are affected by the proposed action and therefore should be included in the action area. The potential concerns are relationships between Dungeness River Hatchery salmon production, and mixed stock fisheries harvest, contribution to the marine food web, and density-dependent interactions affecting salmon growth and survival in the marine environment. However, NMFS has determined that, based on best available science, it is not possible to establish any meaningful causal connection between hatchery production on the scale anticipated in the proposed action and any such effects.

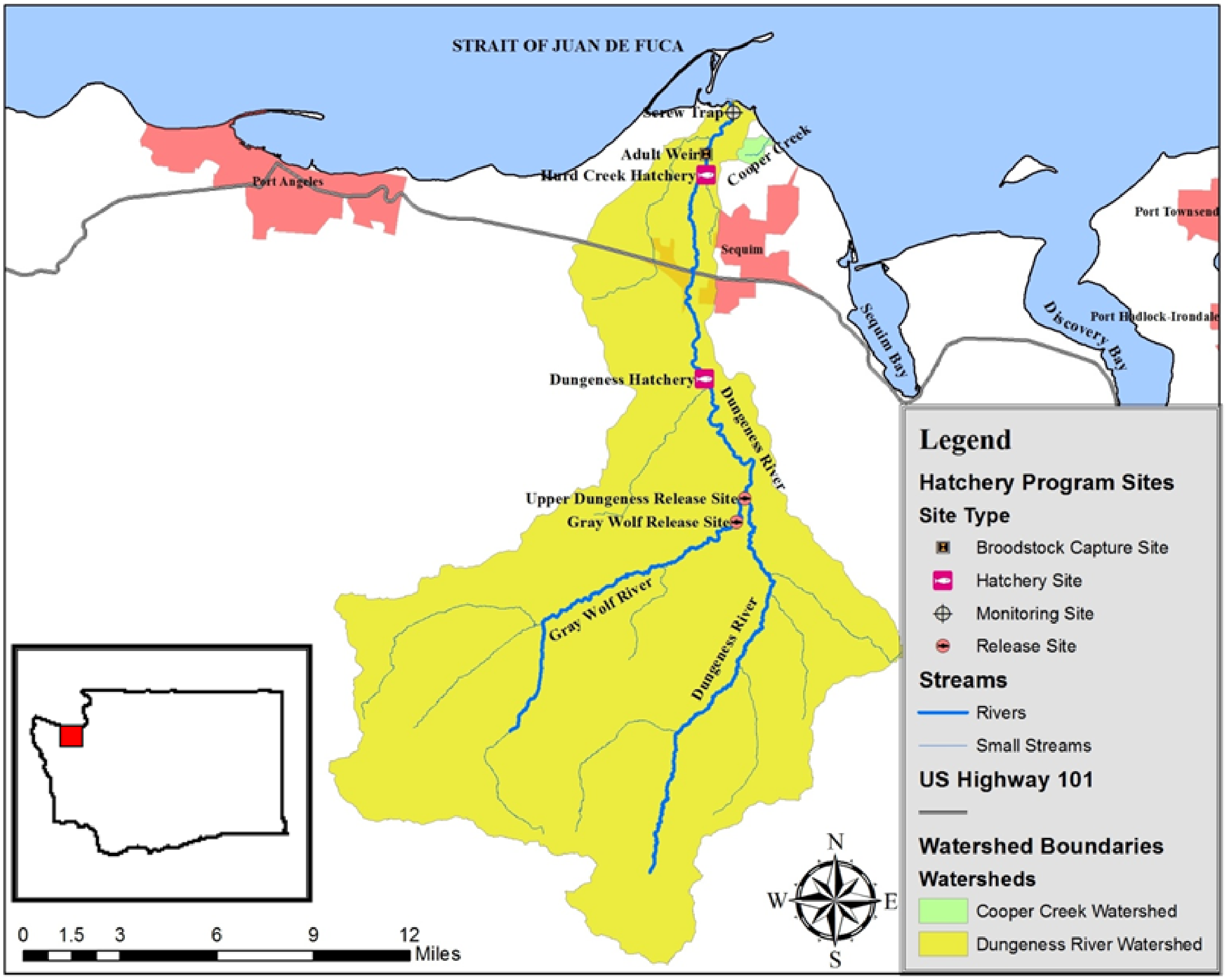

Figure 1. The Dungeness River watershed, adjacent eastern Strait of Juan de Fuca tributaries, and location of Dungeness River Hatchery facilities where the proposed HGMPs would be implemented.

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

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

2.1. Approach to the Analysis

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

This biological opinion relies on the definition of "destruction or adverse modification", which is "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). We will use the following approach to determine whether the proposed action is likely to jeopardize a listed species or destroy or adversely modify critical habitat:

- First, the current range-wide status of listed species and designated critical habitat likely to be adversely affected by the proposed action are described in Section 2.2.
- Next, the environmental baseline in the action area is described in Section 2.3.
- In Section 2.4, we consider how the proposed action would affect the species’ abundance, productivity, spatial structure, and diversity and the proposed action’s effects on critical habitat features.
- Section 2.5 describes the cumulative effects in the action area, as defined in our implementing regulations at 50 CFR 402.02.
- In Section 2.6, the status of the species and critical habitat (Section 2.2), the environmental baseline (Section 2.3), the effects of the proposed action (Section 2.4), and cumulative effects (Section 2.5) are integrated and synthesized to assess the effects of the proposed action on the survival and recovery of the species in the wild and on the conservation value of designated critical habitat.
- Our conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 2.7.
- If our conclusion in Section 2.7 is that the proposed action is likely to jeopardize the continued existence of a listed species or destroy or adversely modify designated critical habitat, we must identify a "Reasonable and Prudent Alternative" (RPA) to the action in Section 2.8.

ESA-listed anadromous salmonid species in the action area (see Section 1.4) are listed in Table 2. The ESA-listed threatened Coastal-Puget Sound bull trout (Salvelinus confluentus) DPS is administered by the U.S. Fish and Wildlife Service (USFWS). Effects on bull trout associated with the NMFS 4(d) rule determination for the proposed hatchery salmon programs have been addressed through a separate ESA section 7 consultation with USFWS. In completing its consultation, USFWS determined that the NMFS action is not likely to jeopardize the continued existence of the bull trout DPS, or to destroy or adversely modify designated critical habitat for the DPS (USFWS 2016). Research and monitoring specifically directed at bull trout in the action area are considered separate actions which would be the subject of separate section 7 consultations (NMFS 2015b). These actions will not be considered as part of the proposed salmon hatchery-related actions addressed in this opinion.

In addition, NMFS has further determined that the proposed action would have no effect on other ESA-listed species under NMFS regulatory purview, including Pacific eulachon, southern resident killer whales, or rockfish. This determination is based on the likely absence of any adverse effects on any of these species, considering the very small proportion of the total numbers of fish present in the areas these ESA-listed species occur that would be represented by Dungeness River Hatchery-origin salmon. Based on these no effect determinations, these species will not be addressed further in this opinion.

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

This opinion examines the status of each species and designated critical habitat that would be affected by the proposed action. The species and the designated critical habitat that are likely to be affected by the proposed action, and any existing protective regulations, are described in Table 2. Status of the species is the level of risk that the listed species face based on parameters considered in documents such as recovery plans, status reviews, and ESA listing determinations. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the status and conservation value of critical habitat in the action area and discusses the current function of the essential physical and biological features that help to form that conservation value.

Table 2. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to ESA listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulation
Chinook salmon (*Oncorhynchus tshawytscha*)			
Puget Sound	Threatened, March 24, 1999; 64 FR 14508	September 2, 2005; 70 FR 52630	June 28, 2005; 70 FR 37160
Steelhead (*Oncorhynchus mykiss*)			
Puget Sound	Threatened, May 11, 2007; 72 FR 26722	September 24, 2016; 81 FR 9252	September 25, 2008; 73 FR 55451

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

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

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

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

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

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

2.2.1. Puget Sound Chinook Salmon ESU

2.2.1.1. Life History and Status

Chinook salmon, *Oncorhynchus tshawytscha,* exhibit a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: “stream-type” and “ocean-type” (Healey 1991; Myers et al. 1998). The proposed action evaluates a program that produces “ocean-type” Chinook salmon, which have very different characteristics compared to “stream type” Chinook salmon. Ocean-type Chinook salmon reside in coastal ocean waters for 3 to 4 years compared to stream-type Chinook salmon that spend 2 to 3 years and exhibit extensive offshore ocean migrations. They also enter freshwater later, upon returning to spawn, than stream-type Chinook salmon: June through September compared to March through July (Myers et al. 1998). Ocean-type Chinook salmon use different areas – they spawn and rear in lower elevation mainstem rivers and they typically reside in fresh water for no more than 3 months compared to stream-type fish, such as spring-run Chinook salmon, that spawn and rear high in the watershed and reside in freshwater for a year.

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case, the Puget Sound Chinook ESU, is at high risk and is threatened with extinction (Table 2)(NWFSC 2015). 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 Puget Sound Chinook on January 19, 2007 (72 FR 2493). The recovery plan consists of two documents: the Puget Sound Salmon Recovery Plan prepared by the Shared Strategy for Puget Sound and NMFS' Final Supplement to the Shared Strategy Plan. The recovery plan describes the population structure, identifies populations essential to recovery of the ESU, establishes recovery goals for most of the populations, and recommends habitat, hatchery and harvest actions designed to contribute to the recovery of the ESU. The plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT)(Ruckelshaus et al. 2002). The PSTRT's Biological Recovery Criteria will be met when the following conditions are achieved:

1. All watersheds improve from current conditions, resulting in improved status for the species;

2. At least two to four Chinook salmon populations in each of the five biogeographical regions of Puget Sound attain a low risk status over the long-term;

3. At least one or more populations from major diversity groups historically present in each of the five Puget Sound regions attain a low risk status;

4. Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario;

5. Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery.

Spatial Structure and Diversity. The PSTRT determined that 22 historical natural populations currently contain Chinook salmon and grouped them into five biogeographical regions (BGRs), based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity (Figure 2; Table 3). Based on genetic and historical evidence reported in the literature, the TRT also determined that there were 16 additional spawning aggregations or populations in the Puget Sound Chinook Salmon ESU that are now putatively extinct[3] (Ruckelshaus et al. 2006).

[3] It was not possible in most cases to determine whether these Chinook salmon spawning groups historically represented independent populations or were distinct spawning aggregations within larger populations.

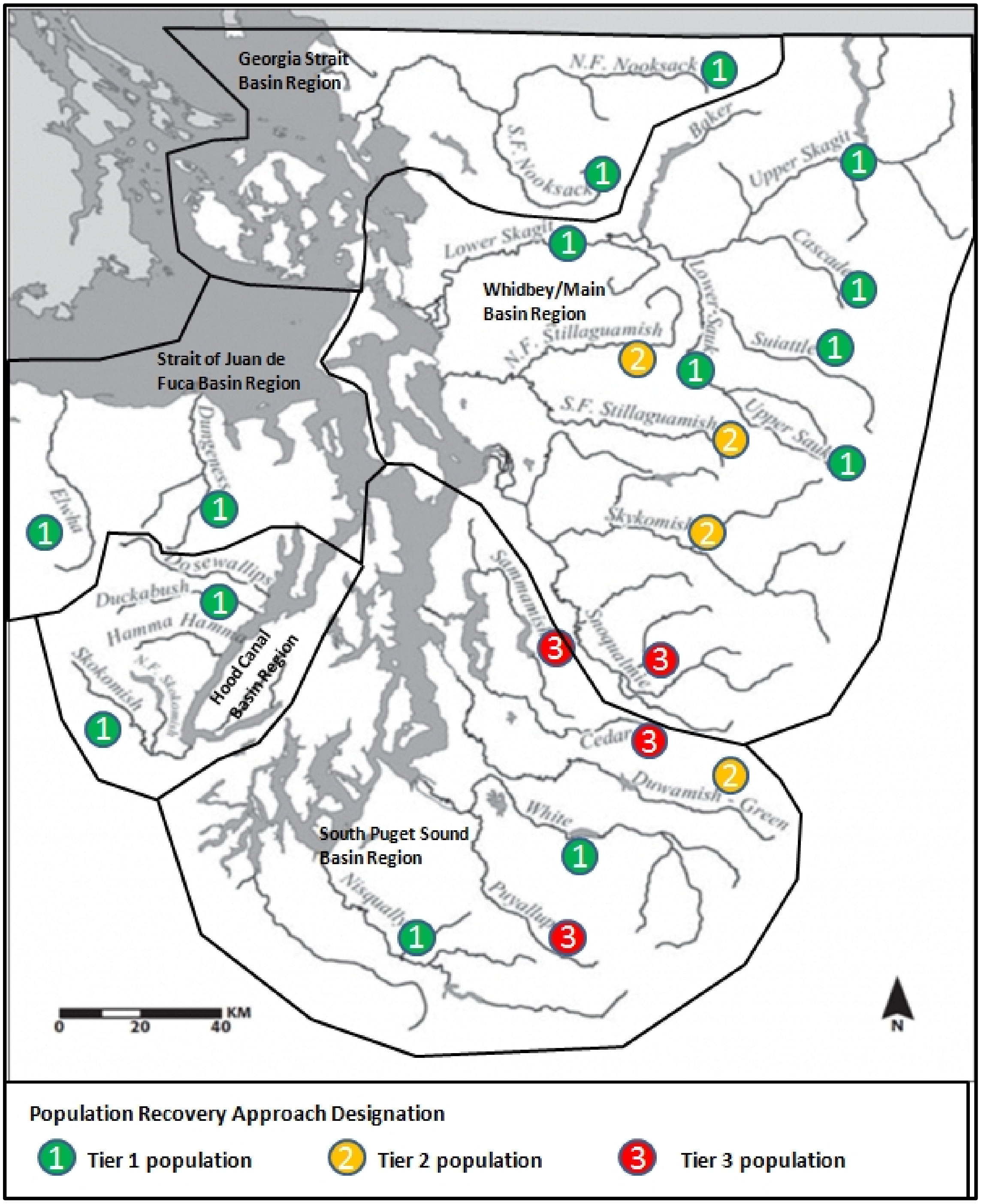

Figure 2. Populations delineated by NMFS for the Puget Sound Chinook salmon ESU (SSPS 2005b) and their assigned Population Recovery Approach tier status (NMFS 2010). Note: Dosewallips, Duckabush and Hamma Hamma River Chinook salmon are aggregated as the "Mid Hood Canal" population.

The ESU encompasses all runs of Chinook salmon from rivers and streams flowing into Puget Sound, including the Strait of Juan de Fuca from the Elwha River eastward, and rivers and streams flowing into Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington. We use the term ''Puget Sound'' to refer to this collective area for salmon. As of 2014, there are 22 artificial propagation programs (described in individual HGMPs) producing Chinook salmon that are included as part of the listed ESU: Kendall Creek Hatchery, Skookum Creek Hatchery, Marblemount Hatchery (two HGMPs - spring and summer-run), Harvey Creek Hatchery, Brenner Creek Hatchery, Whitehorse Springs Hatchery, Wallace River Hatchery, Tulalip Hatchery, Issaquah Hatchery, Soos Creek Hatchery (includes Icy Creek and Palmer Ponds programs), White River Hatchery, White Acclimation Ponds, Hupp Springs Hatchery, Voights Creek Hatchery, Clarks Creek (Diru Creek) Hatchery, Clear Creek Hatchery, Kalama Creek Hatchery, George Adams Hatchery, Hamma Hamma Hatchery, Dungeness River/Hurd Creek Hatchery, and Elwha Channel Hatchery (64 FR 14308, March 24, 1999; 70 FR 37160, June 28, 2005; 71 FR 20802, April 14, 2014).

Table 3. Extant Puget Sound Chinook salmon populations by biogeographical region (NMFS 2006).

Biogeographical Region	**Population (Watershed)**
Strait of Georgia	**North Fork Nooksack River**
	South Fork Nooksack River
Strait of Juan de Fuca	**Elwha River**
	Dungeness River
Hood Canal	**Skokomish River**
	Mid Hood Canal River
Whidbey Basin	Skykomish River (late)
	Snoqualmie River (late)
	North Fork Stillaguamish River (early)
	South Fork Stillaguamish River (moderately early)
	Upper Skagit River (moderately early)
	Lower Skagit River (late)
	Upper Sauk River (early)
	Lower Sauk River (moderately early)
	Suiattle River (very early)
	Upper Cascade River (moderately early)
Central/South Puget Sound Basin	Cedar River (late)
	Sammamish River (late)
	Green/Duwamish River (late)
	Puyallup River (late)
	White River (early)
	Nisqually River (late)

NOTE: NMFS has determined that the bolded populations in particular are essential to recovery of the Puget Sound ESU (NMFS 2006). In addition, at least one other population within the Whidbey Basin (one each of the early, moderately early and late run-timing) and Central/South Puget Sound Basin (one late run-timing) regions would need to be viable for recovery of the ESU.

Indices of spatial distribution and diversity have not been developed at the population level, though diversity at the ESU level is declining. Abundance is becoming more concentrated in fewer populations and regions within the ESU. Abundance has increased particularly within the Whidbey Basin Region (NWFSC 2015). During the last 5-year period (2010-2014) natural-origin escapement in the Strait of Georgia, Strait of Juan de Fuca, Hood Canal, Whidbey Basin, and Central-South Sound BGR's made up

1%, 1%, 2%, 70%, and 26% of the natural-origin escapement, respectively (from Table 56 *in* NWFSC 2015). There is a declining trend in the proportion of natural-origin spawners across the ESU during the entire time period from 1990 through 2014 (NWFSC 2015).

NMFS further classified Puget Sound Chinook salmon populations into three tiers based on its Population Recovery Approach (PRA) using a variety of life history, production and habitat indicators and the Puget Sound Recovery Plan biological delisting criteria (NMFS 2010; NMFS 2011a) (Figure 2). NMFS appreciates and understands that there are non-scientific factors, e.g., the importance of a salmon or steelhead population to tribal culture and economics that are important considerations in salmon and steelhead recovery. Tier 1 populations are of primary importance for preservation, restoration, and ESU recovery. Tier 2 populations play a secondary role in recovery of the ESU and Tier 3 populations play a tertiary role. When NMFS analyzes proposed actions, it evaluates impacts at the individual population scale for their effects on the viability of the ESU. Impacts on Tier 1 populations would be more likely to affect the viability of the ESU as a whole than similar impacts on Tier 2 or 3 populations, because of the primary importance of Tier 1 populations to overall ESU viability.

Abundance and Productivity. Table 4 and Table 5 summarize the available information on current abundance and productivity and their trends for the Puget Sound Chinook populations including NMFS' critical and rebuilding thresholds[4] and recovery plan targets for abundance and productivity. The information is summarized using updated estimates based on methodologies in the recent status review of West Coast salmon ESUs (NWFSC 2015) and recent escapement and fisheries data provided by the co-managers.

Most Puget Sound Chinook salmon populations are well below escapement levels identified as required for recovery to low extinction risk (Table 4). All populations are consistently below productivity goals identified in the recovery plan (Table 4). Although trends vary for individual populations across the ESU, most populations have declined in total natural-origin recruit (NOR) abundance (prior to harvest) since the last status review. However, most populations exhibit a stable or increasing growth rate in natural-origin escapement (after harvest) (Table 5). No clear patterns in trends in escapement or abundance are evident among the five major regions of Puget Sound. No trend was notable for total ESU escapements. Trends in growth rate of natural-origin escapement are generally higher than growth rate of natural-origin abundance indicating some stabilizing influence on escapement from past reductions in fishing-related mortality (Table 5). Survival and recovery of the Puget Sound Chinook Salmon ESU will depend, over the long term, on effective actions in all H sectors. Many of the habitat and hatchery actions identified in the Puget Sound Chinook salmon recovery plan are likely to take years or decades to be implemented and to produce significant improvements in natural population attributes (NWFSC 2015).

[4] The NMFS-derived thresholds are based on population-specific information focused on natural-origin spawners or generic guidance from the scientific literature using methods which are applied consistently across populations in the ESU. A more detailed description of the process NMFS used in deriving these population-specific rebuilding and critical thresholds is presented in Appendix C: Technical Methods - Derivation of Chinook Management Objectives and Fishery Impact Modeling Methods, Final Environmental Impact Statement, Puget Sound Chinook Harvest Resource Management Plan NMFS. 2004. Puget Sound Chinook Harvest Resource Management Plan Final Environmental Impact Statement. NMFS Northwest Region with Assistance from the Puget Sound Treaty Tribes and Washington Department of Fish and Wildlife..

Table 4. Estimates of escapement and productivity (recruits/spawner) for Puget Sound Chinook populations. Natural origin escapement information is provided where available. Populations below their critical escapement threshold are bolded. For several populations, hatchery contribution to natural spawning data are limited or unavailable. Source: NMFS (2011d).

Region	Population	1999 to 2014 Geometric mean Escapement (Spawners)		NMFS Escapement Thresholds		Recovery Planning Abundance Target in Spawners (productivity)[2]	Average % hatchery fish in escapement 1999-2013 (min-max)[5]
		Natural[1]	Natural-Origin (productivity[2])	Critical[3]	Rebuilding[4]		
Georgia Basin	Nooksack MU	1,937	268	*400*	500		
	NF Nooksack	1,638	211 (0.3)	*200*[6]	-	3,800 (3.4)	85 (63-94)
	SF Nooksack	399	53 (1.7)	*200*[6]	-	2,000 (3.6)	84 (62-96)
Whidbey/ Main Basin	Skagit Summer/Fall MU						
	Upper Skagit River	7,976	7,748[8] (1.8)	967	7,454	5,380 (3.8)	3 (1-8)
	Lower Sauk River	543	552[8] (1.8)	*200*[6]	681	1,400 (3.0)	1 (0-10)
	Lower Skagit River	1,993	1,932[8] (1.4)	251	2,182	3,900 (3.0)	4 (2-8)
	Skagit Spring MU						
	Upper Sauk River	522	502[8] (1.6)	130	330	750 (3.0)	1 (0-5)
	Suiattle River	327	319[8] (1.2)	170	400	160 (3.2)	2 (0-5)
	Upper Cascade River	290	291[8] (1.1)	170	*1,250*[6]	290 (3.0)	8 (0-25)
	Stillaguamish MU						
	NF Stillaguamish R.	952	582 (0.9)	300	552	4,000 (3.4)	35 (8-62)
	SF Stillaguamish R.	110	**104** (0.7)	*200*[6]	300	3,600 (3.3)	NA
	Snohomish MU						
	Skykomish River	3,367	2,052[8] (0.9)	1,650	3,500	8,700 (3.4)	30 (8-36)
	Snoqualmie River	1,583	1,142[8] (1.5)	400	*1,250*[6]	5,500 (3.6)	19 (3-62)
Central/ South Sound	Cedar River	842	802[8] (1.9)	*200*[6]	*1,250*[6]	2,000 (3.1)	20 (10-36)
	Sammamish River	1,172	128[8] (0.5)	*200*[6]	*1,250*[6]	1,000 (3.0)	86 (66-95)
	Duwamish-Green R.	3,562	1,179[8] (1.1)	835	5,523	-	57 (33-75)
	White River[9]	1,753	1,268[8] (0.6)	*200*[6]	1,100[7]	-	39 (15-49)
	Puyallup River	1,570	655[8] (0.8)	*200*[6]	522[7]	5,300 (2.3)	53 (18-77)
	Nisqually River	1,687	522[8] (1.0)	*200*[6]	1,200[7]	3,400 (3.0)	72 (53-85)
Hood Canal	Skokomish River	1,305	345 (0.8)	452	1,160	-	66 (7-95)
	Mid-Hood Canal R.[10]	175		*200*[6]	*1,250*[6]	1,300 (3.0)	66
Strait of Juan de Fuca	Dungeness River	354	114[8] (0.6)	*200*[6]	925[7]	1,200 (3.0)	67 (39-96)
	Elwha River[11]	1,919	117[8] (NA)	*200*[6]	*1,250*[6]	6,900 (4.6)	94 (92-95)

[1] Includes naturally spawning hatchery fish. Nooksack spring Chinook 2014 escapements not available.
[2] Source productivity is Abundance and Productivity Tables from NWFSC database; measured as the mean of observed recruits/observed spawners. Sammamish productivity estimate has not been revised to include Issaquah Creek. Source for Recovery Planning productivity target is the final supplement to the Puget Sound Salmon Recovery Plan (NMFS 2006); measured as recruits/spawner associated with the number of spawners at Maximum Sustained Yield under recovered conditions.
[3] Critical natural-origin escapement thresholds under current habitat and environmental conditions (McElhaney et al. 2000; NMFS 2000).
[4] Rebuilding natural-origin escapement thresholds under current habitat and environmental conditions (McElhaney et al. 2000; NMFS 2000).
[5] Estimates of the fraction of hatchery fish in natural spawning escapements are from the Abundance and Productivity Tables and co-manager postseason reports on the Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2013, WDFW and PSTIT 2005, 2006, 2007, 2008, 2009, 2010, 2011a, 2012) and the 2010-2014 Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010a). North Fork and South Fork Nooksack estimates are through 2011 and 2010, respectively. Skagit estimates are through 2011.
[6] Based on generic VSP guidance (McElhaney et al. 2000; NMFS 2000).
[7] Based on alternative habitat assessment.
[8] Estimates of natural-origin escapement for Nooksack, Skagit springs, Skagit falls and Skokomish available only for 1999-2013; Snohomish for 1999-2001 and 2005-2014; Lake Washington for 2003-2014; White River 2005-2014; Puyallup for 2002-2014; Nisqually for 2005-2014; Dungeness for 2001-2014; Elwha for 2010-2014.
[9] Captive broodstock program for early run Chinook salmon ended in 2000; estimates of natural spawning escapement include an unknown fraction of naturally spawning hatchery-origin fish from late- and early run hatchery programs in the White and Puyallup River basins.
[10] South Prairie index area provides a more accurate trend in the escapement for the Puyallup River because it is the only area in the Puyallup River for which spawners or redds can be consistently counted (PSIT and WDFW 2010a).
[11] The Puget Sound TRT considers Chinook salmon spawning in the Dosewallips, Duckabush, and Hamma Hamma rivers to be subpopulations of the same historically independent population; annual counts in those three streams are variable due to inconsistent visibility during spawning ground surveys. Data on the contribution of hatchery fish is very limited; primarily based on returns to the Hamma Hamma River.
[12] Estimates of natural escapement do not include volitional returns to the hatchery or those fish gaffed or seined from spawning grounds for broodstock collection.

Table 5. Trends in abundance and productivity for Puget Sound Chinook populations. Long-term, reliable data series for natural-origin contribution to escapement are limited in many areas (Source: NMFS 2015a).

Region	Population	Natural Escapement and Trend[1] (1990-2013)		Growth Rate[2] (1990-2011)	
				Return (Recruits)	Escapement (Spawners)
Georgia Basin	NF Nooksack (early)	1.14	increasing	1.03	1.02
	SF Nooksack (early)	1.05	increasing	1.02	1.01
Whidbey/Main Basin	Upper Skagit River (moderately early)	1.02	stable	0.97	1.00
	Lower Sauk River (moderately early)	1.00	stable	0.94	0.96
	Lower Skagit River (late)	1.01	stable	0.96	0.99
	Upper Sauk River (early)	1.04	increasing	0.96	1.00
	Suiattle River (very early)	0.99	stable	0.94	0.98
	Upper Cascade River (moderately early)	1.03	increasing	0.98	1.03
	NF Stillaguamish R. (early)	1.01	stable	0.96	1.00
	SF Stillaguamish R[3] (moderately early)	0.96	**declining**	0.90	0.94
	Skykomish River (late)	1.00	stable	0.92	1.02
	Snoqualmie River (late)	1.02	stable	0.93	1.00
Central/South Sound	Cedar River (late)	1.05	increasing	1.01	1.05
	Sammamish River[4] (late)	1.05	stable	0.97	1.01
	Duwamish-Green R. (late)	0.95	**declining**	0.88	0.93
	White River[5] (early)	1.12	increasing	1.06	1.10
	Puyallup River (late)	0.97	**declining**	0.88	0.95
	Nisqually River[3] (late)	1.07	increasing	0.96	0.99
Hood Canal	Skokomish River (late)	1.02	stable	0.88	0.98
	Mid-Hood Canal Rivers (late)	1.04	stable	0.86	0.99
Strait of Juan de Fuca	Dungeness River (early)	1.06	increasing	1.04	1.06
	Elwha River[3] (late)	1.01	stable	0.92	0.97

[1] Escapement Trend is calculated based on all spawners (i.e., including both natural-origin spawners and hatchery-origin fish spawning naturally) to assess the total number of spawners passed through the fishery to the spawning ground. Directions of trends defined by statistical tests.

[2] Growth rate (λ) is calculated based on natural-origin production assuming the reproductive success of naturally spawning hatchery fish is equivalent to that of natural-origin fish (for populations where information on the fraction of hatchery fish in natural spawning abundance is available). Source: Abundance and Productivity Tables-Puget Sound TRT).

[3] Estimate of the fraction of hatchery fish in time series is not available for use in λ calculation, so trend represents that in hatchery-origin + natural-origin spawners.

[4] Growth rate estimates for Sammamish have not been revised to include escapement in Issaquah Creek.

[5] Natural spawning escapement includes an unknown fraction of naturally spawning hatchery-origin fish from late- and early run hatchery programs in the Puyallup River basin.

For the purpose of assessing population status, NMFS has derived critical and rebuilding escapement thresholds for some of the Puget Sound Chinook salmon populations based on an assessment of current habitat and environmental conditions (NMFS 2000; NMFS 2004; NMFS 2011a). The 2015 status review concluded that total abundance in the ESU over the entire time series shows that individual populations have varied from increasing or decreasing abundance; generally, many populations increased in abundance during the years 2000 through 2008 and then declined in the last five years (NWFSC 2015). Abundance across the ESU has generally decreased since the last status review, with only 5 populations showing an increase in abundance in the 5-year geometric mean natural-origin abundance since the 2010 status review (NWFSC 2015). The remaining 17 populations showed a decline in their 5-year geometric mean natural-origin abundance as compared to the previous 5-year period. The 5-year geometric mean abundance for the entire ESU was 27,716 natural -origin adults from 2005 through 2009 and only 19,258 from 2010 through 2014; indicating an overall decline of -31% (from Table 56 *in* NWFSC 2015). Geometric mean (1999-2014) natural-origin escapements for 5 of the 22 populations are above their NMFS-derived rebuilding thresholds (Table 4). Geometric mean (1999-2014) escapements for ten of the 22 populations are between their critical and rebuilding thresholds. Geometric mean (1999-2014) natural-origin escapements are below their critical thresholds for seven populations (Table 4). The most recent geometric mean (2010-2014) natural-origin escapements indicate that 8 populations are currently below their critical thresholds.

Limiting factors. Limiting factors for the ESU described in Ruckelshaus et al. (2005) and NMFS (2011a) include:

- Degraded nearshore and estuarine habitat: Residential and commercial development has reduced the amount of functioning nearshore and estuarine habitat available for salmon rearing and migration. The loss of mudflats, eelgrass meadows, and macroalgae further limits salmon foraging and rearing opportunities in nearshore and estuarine areas.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, and water quality have been degraded for adult spawning, embryo incubation, and rearing as a result of cumulative impacts of agriculture, forestry, and development.
- Anadromous salmonid hatchery programs: Salmon and steelhead released from Puget Sound hatcheries operated for harvest augmentation purposes pose ecological, genetic, and demographic risks to natural-origin Chinook salmon populations.
- Salmon harvest management: Dungeness Chinook salmon are harvested at very low levels (6%) in southern U.S. mixed-stock marine area fisheries targeting more abundant Chinook salmon stocks and other species returning to other areas outside the action area (this and following from PSIT and WDFW 2010b; WDFW and PSIT 2010). Total fishery exploitation rates have decreased 14 to 63 percent from rates in the 1980s, but weak natural-origin Chinook salmon populations in Puget Sound still require enhanced protective measures to reduce the risk of overharvest. Managers will continue to constrain fishery impacts on Dungeness Chinook salmon. Incidental harvest of Dungeness River Chinook salmon occurs predominantly in Canadian and Alaskan troll, sport, and net fisheries, which account for an estimated 13% of total recoveries (all fisheries plus escapement) of coded wire-tagged subyearling fish released through the Dungeness River Hatchery program (data for subyearling fish released from the Gray

Wolf Pond (WDFW 2013a). Canadian and Alaskan fishery impacts on U.S. Chinook salmon populations are managed and limited in accordance with U.S./Canada Pacific Salmon Treaty harvest sharing agreements. Estimated average total exploitation rates for Dungeness Chinook from 1983 to 2010 declined by 45 and 86 percent in all fisheries and southern U.S. fisheries, respectively (Bishop 2013).

The severity and relative contribution of these factors varies by population. One theory for the declines in fish populations in Puget Sound in the 1980s and into the 1990s is that they may reflect broad-scale shifts in natural limiting conditions, such as increased predator abundances and decreased food resources in ocean rearing areas. These factors are discussed in more detail in the Environmental Baseline (Section 2.3).

Strait of Juan de Fuca BGR

The Strait of Juan de Fuca BGR contains two Chinook salmon populations: Dungeness and Elwha. Both populations would need to be viable for recovery of the ESU (NMFS 2006). The Dungeness and Elwha are early and late-timed populations, respectively, although both basins historically exhibited components across the run-timing spectrum (Ruckelshaus et al. 2006). Evidence suggests that much of the life-history diversity represented by early-type populations or population components that existed historically in the Puget Sound Chinook ESU has been lost (Ruckelshaus et al. 2006) so protection of the remaining early-type populations like the Dungeness is particularly important to recovery of the ESU. Genetic and ocean distribution data indicate the Elwha population is intermediate between Puget Sound and Washington coastal populations and considered to be a transitional population between the Puget Sound and Washington Coastal Chinook salmon ESUs (Myers et al. 1998). The BGR currently accounts for 1.5% of the natural-origin Chinook salmon escapement in the ESU (from Table 56 *in* NWFSC 2015). Based on the available information, both populations in the BGR are below their critical thresholds; and spawning escapements are supplemented with hatchery fish to reduce short-term demographic risk. Escapement trends and growth rates derived by NMFS NWFSC through its Abundance and Productivity Puget Sound TRT database indicate the trend and rate for the Dungeness population is above 1.0 and increasing. The same analyses indicate the escapement trend and growth rate are stable or declining for the Elwha population (Table 5). Both populations have on-going conservation supportive breeding programs to increase the number of natural spawners and reduce extinction risk, in the short-term. These supportive breeding programs are considered essential components to the recovery strategies for both populations (NMFS 2012b; SSPS 2005b; Ward et al. 2008). The Elwha River watershed is undergoing a substantial restoration effort associated with removal of the two dams, which will restore salmon access to 70 miles of spawning and rearing habitat (Ward et al. 2008). In summary, populations within the Strait of Juan de Fuca BGR exhibit life history components unique within the ESU and present significant challenges to ESU recovery given their critical status.

Dungeness Population

The extant Dungeness Chinook salmon population is considered a spring/summer-run timed (or “early”) population, based on spawn timing. The population spawns in the watershed from mid-August to mid-October (WDFW and WWTIT 1994). Chinook salmon spawn in the mainstem Dungeness River up to RM 18.7, where natural falls block further access. Spawning distribution in recent years has been weighted toward the lower half of the accessible river reach, with approximately two-thirds of redds located downstream of RM 10.8. There have been no major shifts in spawning distribution from lower to mid and upper river areas over the periods 1991-1999 (44% of redds in the lower 6.4 miles) and 2000 to 2013 (40% in the lower 6.4 miles) (M. Haggerty, Haggerty Consulting, and R. Cooper, WDFW, unpublished WDFW data, September 17, 2014). Chinook salmon also spawn in the Gray Wolf River (confluence with Dungeness at RM 15.8) up to RM 5.1 (WDFW and WWTIT 1994). When including the Gray Wolf River, total spawning distribution in the lower river decreased from 44% to 38% over the two above periods. Chinook salmon typically spawn first in the upstream reaches. As the season progresses, spawning occurs further downstream in the lower mainstem reaches (WDF et al. 1993).

Dungeness Chinook salmon predominantly exhibit an ocean-type life history trajectory (Myers et al. 1998), with juveniles emigrating seaward from mid-February through the end of July (Topping et al. 2006). A small portion of the population (< 5 %) may rear in the river for a year and emigrate seaward as yearlings (Marlowe et al. 2001; (SSPS 2005a). Adults mature primarily at age four (63%), with age-3 and age-5 adults comprising 10% and 25%, of the annual returns, respectively (PSIT and WDFW 2010a). Recent data indicate that Dungeness River Hatchery-origin sub-yearlings return as adults at the following age class proportions: Age 2 (8%), 3 (36%), 4 (48%), 5 (8%), and 6 (0%) (M. Haggerty, pers. comm., September 16, 2014). Dungeness River Hatchery yearling Chinook salmon adults return at Age 2 (1%), 3 (17%), 4 (56%), 5 (23%), and 6 (3%).

The current abundance of Dungeness Chinook salmon is substantially reduced from historical levels (SSPS 2005a) (Table 4). Between 2001 and 2014, the estimated average total annual naturally spawning Chinook salmon escapement was 94 natural-origin spawners compared with the recovery goal at high productivity of 1,200 natural-origin spawners (see Table 4) (NMFS 2006; Ruckelshaus et al. 2002). Assessments of current habitat productivity in the watershed suggest that the Dungeness River can theoretically support 699 (SSPS 2005a) to 925 (B. Sele, WDFW, pers. comm.) spawning Chinook salmon. Hatchery-origin Chinook salmon associated with the Dungeness conservation hatchery program make up a sizeable fraction of the annual naturally spawning adult abundance, averaging 72% for the basin (range=39-96%) (Figure 3). The proportion of the total naturally spawning Chinook salmon escapements that were of natural-origin within the following 3 time periods - 2000-2004, 2005 -2009, and 2010-2014 - averaged 15%, 43%, and 24%, respectively (WDFW, unpublished spawning ground survey data). Total naturally spawning fish escapements have fluctuated with changes in the conservation hatchery program with the highest escapements reflecting years when adult progeny from the hatchery program returned to spawn (PSIT and WDFW 2010a). Between 2001 and 2014, the geometric mean total annual naturally spawning Chinook salmon escapement was approximately 391 fish (Figure 3). Total annual naturally spawning Chinook salmon escapement for the most recent 6 years has averaged 297 (range 535 to 98); with 213 and 85 fish on average being hatchery-origin and natural-origin, respectively..

Estimates derived from the Puget Sound TRT Abundance and Productivity table database suggest that productivity for Dungeness Chinook salmon has increased since the Puget Sound

Chinook Salmon ESU was listed in 1999 (Table 5). The most recent NMFS status review for the ESU found that productivity trends for the Dungeness Chinook salmon population, as measured by recruit per spawner and spawner to spawner rates, are low and decreasing (NWFSC 2015). Although the slight increases in the NMFS (2015a) spreadsheet-derived rates indicate productivity has increased, NWFSC (2015) reported that natural spawner-to-spawner productivity for the Dungeness Chinook population has been below replacement levels in all years since the mid-1980s. Estimates for juvenile Chinook salmon outmigrant production for brood year 2004-2014 ranged from a high of 164,814 out-migrating fish in 2013 to a low of 3,870 outmigrants in 2015 (PSIT and WDFW 2010a - data from WDFW juvenile outmigrant monitoring annual report series, including Topping et al. 2006; 2008). Estimated egg to migrant survival has ranged from 1.4% to 14.7% and averaged 4.9% for return years 2004 through 2014 (Figure 4). For comparison, in the Skagit River, where natural habitat is in better condition for Chinook salmon productivity, egg to smolt survival estimates averaged over 10% from brood year 1990 to 2006 (Kinsel et al. 2008).

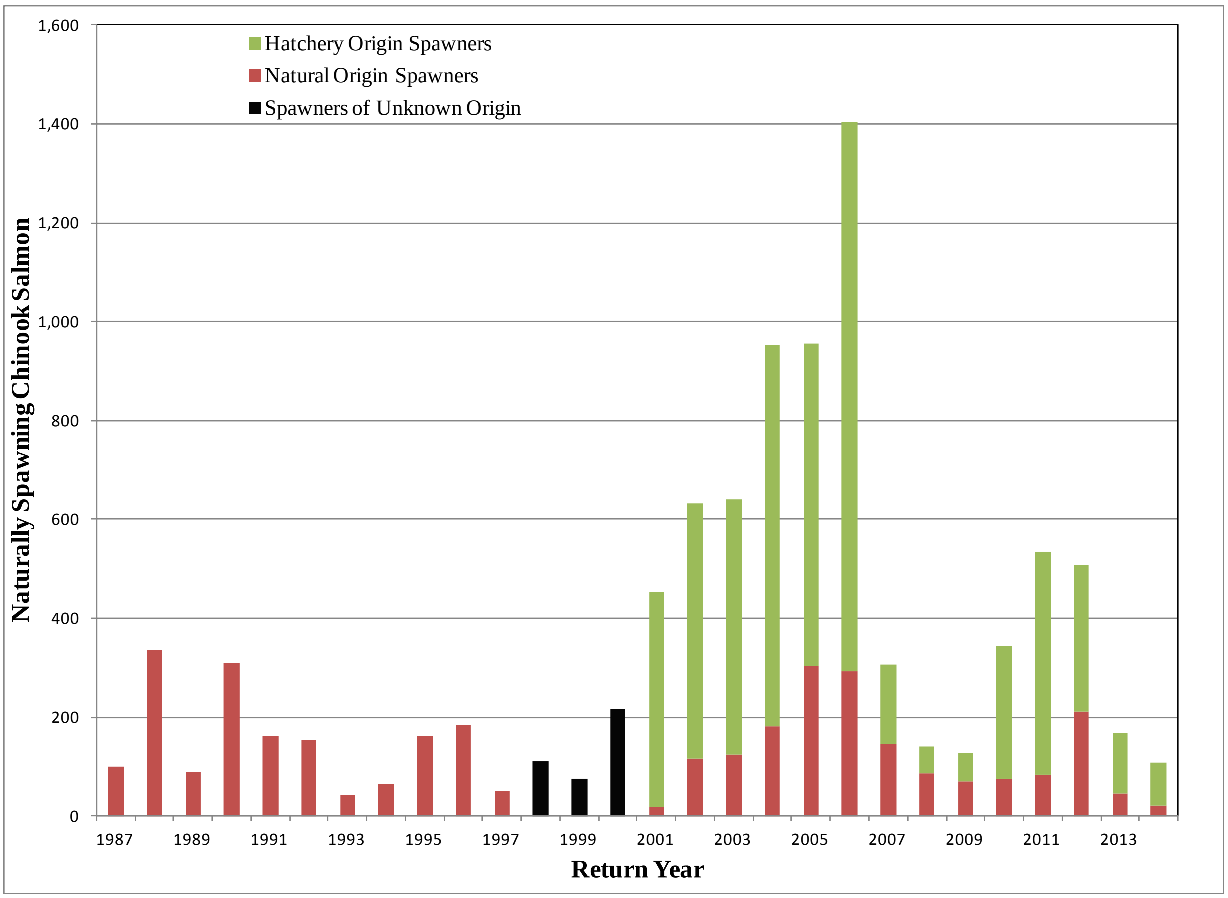

Figure 3. Estimated annual naturally spawning Chinook salmon escapement abundance (natural and hatchery-origin salmon combined) in the Dungeness River for 1987 – 2014. Data sources: PSIT and WDFW 2010; WDFW unpublished data 2015, accessed via: https://fortress.wa.gov/dfw/score/score/species/population_details.jsp?stockId=1240

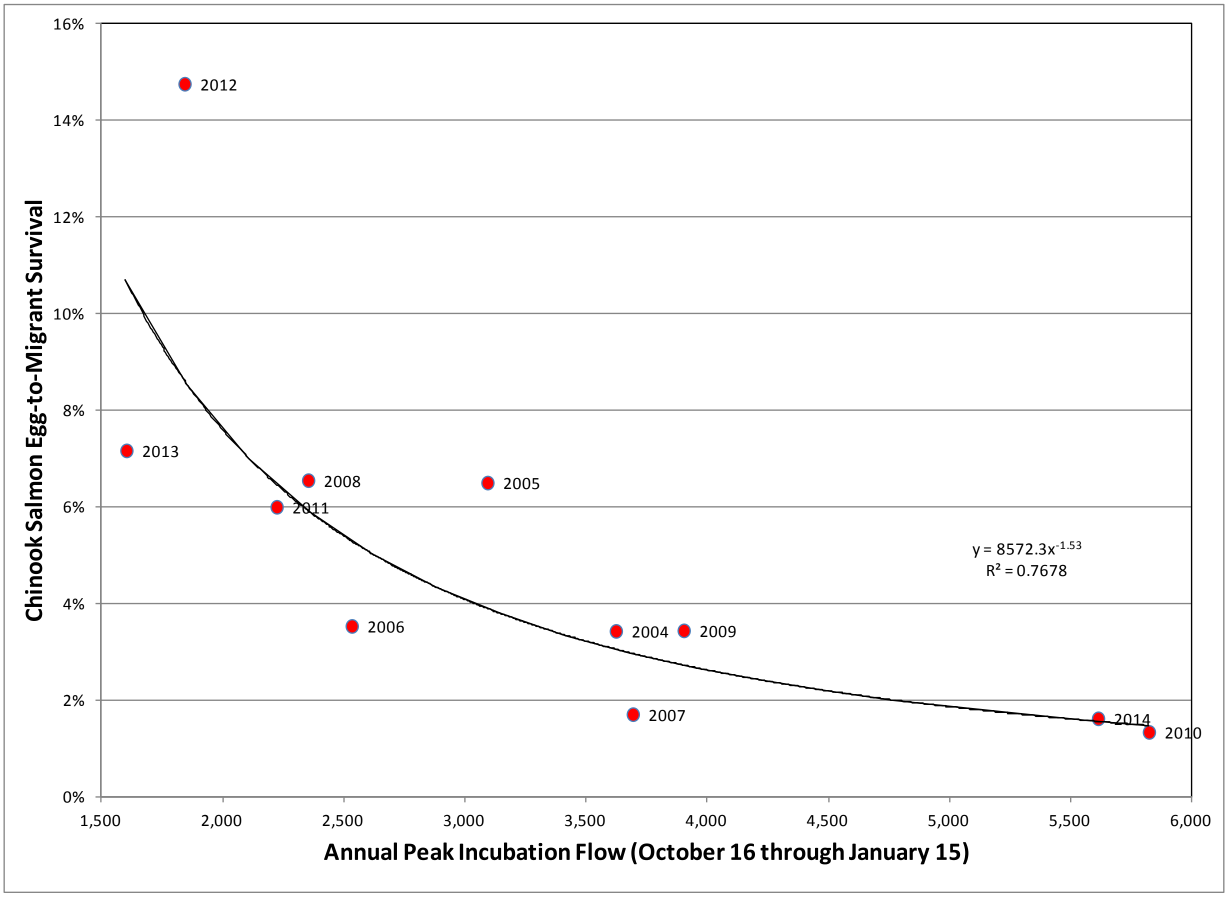

Figure 4. Natural-origin 0+ Chinook egg-to-migrant survival and annual peak incubation flow for brood years 2004 through 2014 in the Dungeness River. (Assumes 5,500 eggs per female based on average fecundity of brood stock from 2005-2007, 2010, and 2011). Data sources: Topping et al., 2006; Topping and Kishimoto 2008; Topping et al. 2008; updates to annual juvenile abundance estimates presented in these reports from Pete Topping, WDFW, pers. comm., February 2016, and accessed at: http://wdfw.wa.gov/conservation/research/projects/puget_sound_salmonids/dungeness/index.htm

Spatial structure for the Dungeness Chinook population has also been affected over time relative to historical levels. A full spanning weir at RM 10.8 operating in association with the Dungeness River Hatchery program from the 1930s to the 1980s, precluded unrestricted upstream access by Chinook salmon and spawning in the upper Dungeness River watershed for 50 years, although some Chinook salmon were known to have regularly escaped upstream during that period (Haring 1999; SSPS 2005a). Chinook salmon continue to have access to their historical geographic range of habitat[5], and now spawn throughout the entire watershed. Low adult return levels in recent years have led to underutilization of accessible areas, especially in the Gray Wolf River (SSPS 2005a). Dikes, levees, and other actions to control the lower reaches of the river and tributaries have adversely affected population spatial structure, particularly through adverse impacts on side-channel habitat and increased scour of redds (Haring 1999). These actions have degraded available spawning and migration areas for adult fish, and refugia for rearing juvenile salmon. Finally, water withdrawals have

[5] The portion of critical habitat for Chinook salmon upstream of the Canyon Creek water diversion will become accessible to migrating Chinook salmon in fall 2017.

substantially reduced flows needed during the adult salmon upstream migration and spawning periods, forcing adults to construct spawning redds in channel areas that are extremely susceptible to sediment scour and aggradation.

Genetic diversity of the Dungeness Chinook salmon population has been substantially impacted by anthropogenic activities over the last century. Although run-timing appears to be unchanged over time, given the loss of side-channel and estuarine habitat associated with development in the watershed, a number of life-history pathways have been lost (Clallam County and Jamestown S'Klallam Tribe 2005). Genetic diversity has been reduced, as modeling estimates that only 70% of the historical pathways remain available to the Dungeness Chinook population (Clallam County and Jamestown S'Klallam Tribe 2005). Diversity of the population has been impacted, not by loss of sub-populations, but through the loss of life history pathways associated with specific habitat types (Clallam County and Jamestown S'Klallam Tribe 2005). Extensive human disruptions in the watershed, including sporadic releases of non-native hatchery fall Chinook salmon in the last century, may have severely impacted a late-returning life history of Chinook salmon that existed in the watershed; a significant part of the historical diversity of the population (Ruckelshaus et al. 2006, citing Williams et al. 1975; Tribe 2007).

A recent captive broodstock program that was terminated in 2004, could have also affected genetic diversity of the Dungeness River Chinook salmon population. In founding the original hatchery program, the risk of within population genetic diversity loss was reduced by selecting the indigenous Chinook salmon population for use as captive broodstock. Further, the duration of the captive broodstock program was limited to a six-year period (1992 through 1997 broods) to reduce the risk of genetic diversity loss that may occur as a result of captive breeding. Continuing effects of hatchery operations in the action area are discussed in section 2.3.2, below.

Recent assessments indicate that only one Chinook salmon stock with no discontinuity in spawning distribution through time or space exists in the basin (Ruckelshaus et al. 2006, citing Marlowe et al. 2001). As discussed previously, the disproportionate loss of early-run life history diversity represents a particularly significant loss of the evolutionary legacy of the historical ESU. The substantially reduced abundance of the Dungeness spring/summer-run population relative to historical levels represents a risk to remaining ESU diversity.

2.2.1.2. Status of Critical Habitat for Puget Sound Chinook Salmon

Designated critical habitat for the Puget Sound Chinook Salmon ESU includes estuarine areas and specific river reaches associated with the following sub-basins: 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 (70 FR 52630, September 2, 2005). The designation also includes some nearshore areas extending from extreme high water out to a depth of 30 meters and adjacent to watersheds occupied by the 22 extant natural populations because of their importance to rearing and migration for Chinook salmon and their prey, but does not otherwise include offshore marine areas. There are 61 watersheds (HUC5 basins) within the range of this ESU. Twelve watersheds received a low rating, nine received a medium rating, and 40 received a high rating of conservation value to the ESU (NMFS 2005a). Nineteen nearshore marine areas also received a rating of high conservation value. Of the 4,597 miles of stream and nearshore habitat eligible for designation, 3,852 miles are designated critical habitat (NMFS 2005b).

NMFS determines the range-wide status of critical habitat by examining the condition of its physical and biological features (also called "primary constituent elements," or PCEs, in some designations) that were identified when the critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). PCEs for Puget Sound Chinook salmon (70 FR 52731, September 2, 2005), including the Dungeness salmon population, include:

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

The Dungeness watershed and associated nearshore area received high conservation value ratings. Critical habitat is designated for Puget Sound Chinook in the Dungeness River watershed action area. Critical habitat also encompasses the estuarine areas and adjacent riparian zones in Dungeness Bay. Within the watershed, critical habitat extends from the outlet of the Dungeness River upstream to the limits of Chinook salmon access in the Dungeness River mainstem, Gray Wolf River, Matriotti Creek, and an unnamed tributary (located at latitude 48.1514, longitude –123.1216), and includes a lateral extent as defined by the ordinary high-water line (33 CFR 319.11). The Puget Sound Critical Habitat Analytical Review Team identified management activities that may affect the PCEs in the Dungeness Basin including irrigation, channel modifications/diking, forage fish/species harvest, forestry, urbanization, sand/gravel mining, and road building/maintenance (NMFS 2005a).

2.2.2. Puget Sound Steelhead DPS

2.2.2.1. Life History and Status

Oncorhynchus mykiss has an anadromous form, commonly referred to as steelhead, of which Puget Sound steelhead are a DPS. Steelhead exhibit a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. They depend on freshwater areas for spawning and rearing, and marine environments for growth and maturation. Steelhead differ from other Pacific salmon in that they are iteroparous or capable of spawning more than once before death. Adult steelhead that have spawned and returned to the ocean are often referred to as kelts. Averaging across all West Coast steelhead populations, eight percent of spawning adults have spawned previously, with coastal populations containing a higher incidence of repeat spawning compared to inland populations (Busby et al. 1996). Steelhead express two major life history types. Summer steelhead enter freshwater at an early stage of maturation beginning in the late spring, migrate to headwater areas and hold until spawning in the winter and following spring. Winter steelhead typically enter freshwater at an advanced stage of maturation later in the year and spawn in the winter and spring (Busby et al. 1996; Hard et al. 2007).

Puget Sound steelhead are dominated by the winter life history type and typically migrate as smolts to sea at age two, with smaller numbers of fish emigrating to the ocean between one to three years of age. Seaward emigration commonly occurs from April to mid-May, with fish typically spending one to three years in the ocean before returning to freshwater. They migrate directly offshore during their first summer rather than migrating nearer to the coast as do salmon. During fall and winter, juveniles move southward and eastward (Hartt and Dell 1986). Adults from extant populations of winter steelhead return from December to May, and peak spawning occurs in March through May. Summer steelhead adults return from May through October and peak spawning occurs the following January to May (Hard et al. 2007). Temporal overlap exists in spawn timing between the two life history types, particularly in northern Puget Sound where both summer and winter steelhead are present, although summer-run steelhead typically spawn farther upstream above obstacles that are largely impassable to winter steelhead (Behnke and American Fisheries Society 1992; Busby et al. 1996). The proposed action evaluates programs that could affect the summer/winter steelhead population in the Dungeness River Basin.

This Puget Sound steelhead DPS was listed as threatened in May of 2007 (Table 2). As part of the recovery planning process, NMFS convened the Puget Sound Steelhead Technical Recovery Team (PSSTRT) to identify historical populations and develop viability criteria for the recovery plan. The PSSTRT has produced considerable new science that is available for management and affects evaluation purposes. Their final report describing natural population structure was released in March, 2015 (Myers et al. 2015) and viability criteria for Puget Sound steelhead were issued in May, 2015 (Hard et al. 2015).

No new estimates of productivity, spatial structure, and diversity for Puget Sound steelhead have been made available since the 2007 review, when the Biological Review Team (BRT) concluded that low and declining abundance and low and declining productivity were substantial risk factors for the species (Hard et al. 2007). Loss of diversity and spatial structure were judged to be "moderate" risk factors due to reduced complexity and diminishing connectivity among populations, influences of non-native hatchery programs and the low numbers of extant summer steelhead populations in the Puget Sound DPS (Hard et al. 2007). The 2011 status review (Ford et al. 2011) retained the risk category for the DPS based upon the extinction risk of the component natural populations. The PSSTRT recently concluded that the DPS was at very low viability, as were all three of its MPGs, and many of the "Demographically Independent Populations" (DIPs) (Hard et al. 2015; Table 6). In spring 2016, the Northwest Fishery Science Center completed an updated five-year review of the status of the DPS. This status review update concludes that biological risks faced by the DPS have not substantively changed since listing in 2007, and the viability status of the DPS and component MPGs continued to be very poor (NWFSC 2015).

The PSSTRT has completed a set of population viability analyses (PVAs) for these populations and major population groups (MPGs) within the DPS. The roles of individual populations in recovery of the DPS have not yet been defined. However, the PSSTRT developed interim abundance-based guidelines for various potential recovery scenarios stating that in order for the DPS to achieve full recovery, steelhead populations in the DPS need to be robust enough to withstand natural environmental variation and even some catastrophic events, and should be resilient enough to support harvest and habitat loss due to human population growth (Hard et al. 2015).

Spatial Structure and Diversity. The Puget Sound steelhead DPS includes all naturally spawned anadromous winter-run and summer-run steelhead populations in river and stream basins 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) (Figure 5). Also included as part of the ESA-listed DPS are six hatchery-origin stocks derived from native steelhead populations and produced for conservation purposes, including fish from the Green River Natural Program; White River Winter Steelhead Supplementation Program; Hood Canal Steelhead Supplementation Off-station Projects in the Dewatto, Skokomish, and Duckabush Rivers; and the Lower Elwha Fish Hatchery Wild Steelhead Recovery Program (FR 79 20802, April 14, 2014). Non-anadromous ''resident'' *O. mykiss* occur within the range of Puget Sound steelhead but are not part of the DPS due to marked differences in physical, physiological, ecological, and behavioral characteristics (Hard et al. 2007). The Puget Sound steelhead populations are aggregated into three extant MPGs containing a total of 32 DIPs based on genetic, environmental, and life history characteristics ((Myers et al. 2015)(Table 6). DIPs can include summer steelhead only, winter steelhead only, or a combination of summer and winter run timing (i.e., summer / winter).

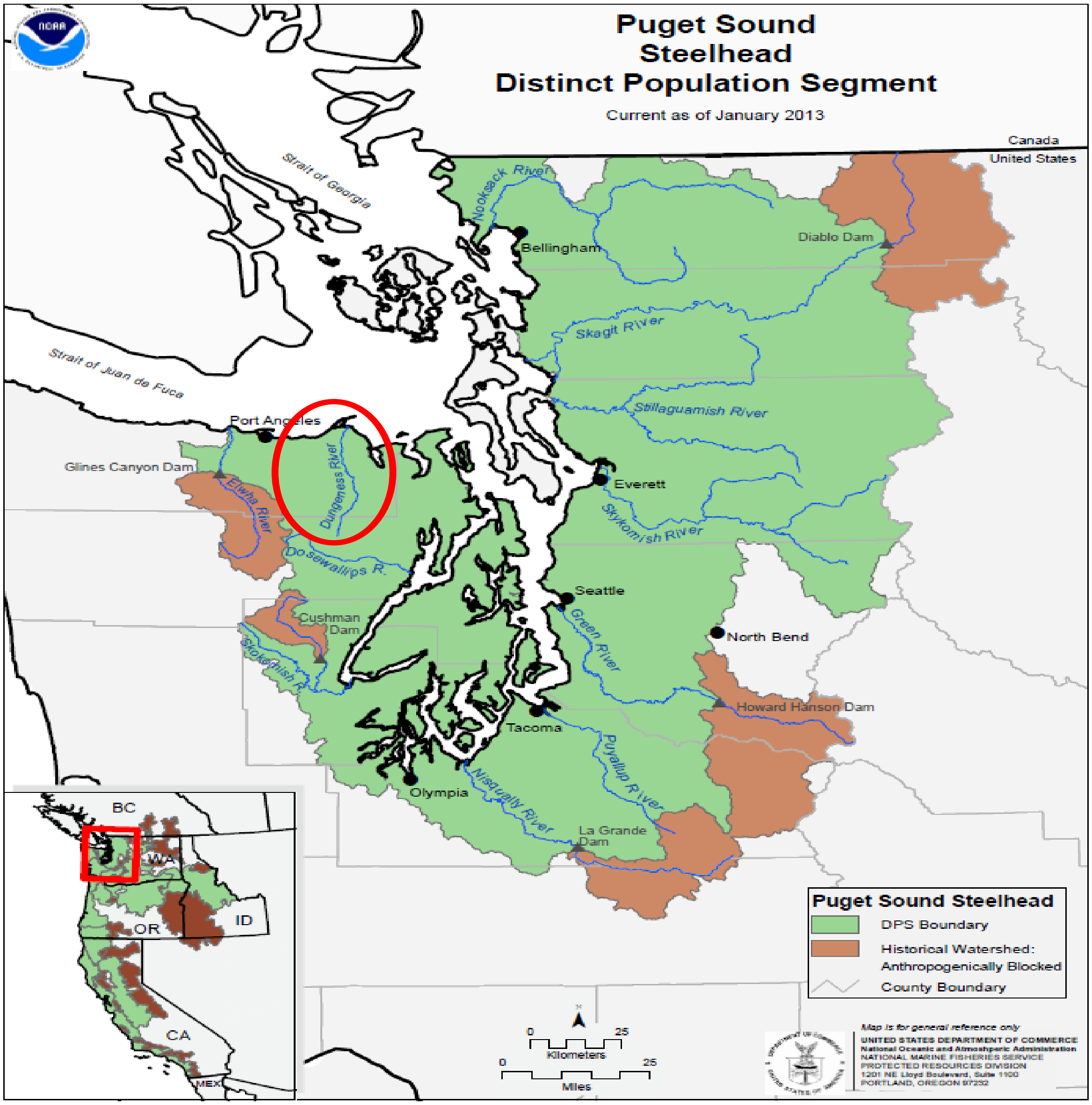

Figure 5. Location of Dungeness steelhead population in the Puget Sound Steelhead DPS (indicated by circle).

Abundance and Productivity. The 2007 BRT considered the major risk factors facing Puget Sound steelhead to be: widespread declines in abundance and productivity for most natural steelhead populations in the ESU, including those in Skagit and Snohomish rivers (previously considered to be strongholds); the low abundance of several summer-run populations; and the sharply diminishing abundance of some steelhead populations, especially in south Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Hard et al. 2007).

The 2015 status review (NWFSC 2015) concluded that the most recent data available indicate some minor increases in spawner abundance and/or improving productivity over the last two to three years; however, most of these improvements are viewed as small and abundance and productivity throughout the DPS remain at levels of concern from demographic risk. For all but a few putative PS steelhead populations, estimates of mean population growth rates obtained from observed spawner or redd counts are declining—typically 3 to 10 percent annually—and extinction risk within 100 years for most populations in the DPS is estimated to be moderate to high, especially for populations in the Central and South Puget Sound and Hood Canal and Strait of Juan de Fuca MPGs (Table 6). NWFSC (2015) found that recent increases in abundance observed in a few populations have been within the range of variability observed in the past several years and trends in abundance of natural spawners remain predominantly negative. Declining production of both summer-run and winter-run hatchery steelhead, as well as reduced harvest have limited biological risks to the natural spawners in recent years. In general, the biological risks faced by the Puget Sound Steelhead DPS have not substantively changed since the listing in 2007, or since the 2011 status review (NWFSC 2015).

Limiting factors. In its status reviews of the Puget Sound Steelhead DPS (e.g., NWFSC 2015; 76 FR 1392, January 10, 2011; 71 FR 15666, March 29, 2006), NMFS noted that the factors for decline for the DPS also persist as limiting factors:

- In addition to being a factor that contributed to the present decline of Puget Sound steelhead populations, the continued destruction and modification of steelhead habitat is the principal factor limiting the viability of the Puget Sound steelhead DPS into the foreseeable future.
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years.
- Threats to diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania) inconsistent with wild stock diversity throughout the DPS.
- Declining diversity in the DPS, including the uncertain but weak status of summer-run fish in the DPS.
- A reduction in spatial structure for steelhead in the DPS. Large numbers of barriers, such as impassable culverts, together with declines in natural abundance, greatly reduce opportunities for adfluvial movement and migration between steelhead groups within watersheds.
- Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris.
- Increased flood frequency and peak flows during storms, reduced groundwater-driven summer flows in the lower reaches of many rivers and their tributaries in Puget Sound where urban development has occurred, has resulted in gravel scour, bank erosion, and sediment deposition.
- Dikes, hardening of banks with riprap, and channelization, which have reduced river braiding and sinuosity, have increased the likelihood of gravel scour and dislocation of rearing juveniles.

Table 6. Puget Sound steelhead populations and risk of extinction (Hard et al. 2015)

Geographic Region (MPGs)	Population (Run Time)	Extinction Risk (probability of decline to an established quasi-extinction threshold (QET) for each population)	Quasi-extinction threshold (number of fish)
Northern Cascades	Drayton Harbor Tributaries (winter)	Unable to calculate	
	SF Nooksack River (summer)	Unable to calculate	
	Nooksack River (winter)	Unable to calculate	
	Samish River/Bellingham Bay (winter)	Low—about 30% within 100 years	31
	Skagit River (summer/winter)	Low—about 10% within 100 years.	157
	Baker River (summer/winter)	Unable to calculate	
	Sauk River (summer/winter)	Unable to calculate	
	Snohomish/Skykomish River (winter)	Low—about 40% within 100 years	73
	Stillaguamish River (winter)	High—about 90% within 25 years	67
	Deer Creek (summer)	Unable to calculate	
	Canyon Creek (summer)	Unable to calculate	
	Tolt River (summer)	High—about 80% within 100 years	25
	NF Skykomish River (summer)	Unable to calculate	
	Snoqualmie (winter)	High---about 70% within 100 years	58
	Nookachamps (winter)	Unable to calculate	--
	Pilchuck (winter)	Low---about 40% within 100 years	34
Central and Southern Cascades	North L. Washington/L. Sammamish (winter)	Unable to calculate	
	Cedar River (summer/winter)	High---about 90% within the next few years	36
	Green River (winter)	Moderately High—about 50% within 100 years	69
	Nisqually River (winter)	High—about 90% within 25 years	55
	Puyallup/Carbon River (winter)	High—about 90% within 25-30 years	
	White River (winter)	Low—about 40% within 100 years	64
	South Sound Tributaries (winter)	Unable to calculate percentage	--
	East Kitsap (winter)	Unable to calculate	
Hood Canal and Strait of Juan de Fuca	Elwha River (summer[6]/winter)	High— about 90% currently	41
	Dungeness River (summer/winter)	High—about 90% within 20 years	30
	South Hood Canal (winter)	High---about 90% within 20 years	30
	West Hood Canal (winter)	Low—about 20% within 100 years	32
	East Hood Canal (winter)	Low—about 40% within 100 years	27
	Skokomish River (winter)	High—about 70% within 100 years	50
	Sequim/Discovery Bay Independent Tributaries (winter)	High—about 90% within 100 years (Snow Creek)	25 (Snow Creek)
	Strait of Juan de Fuca Independent Tributaries (winter)	High—about 90% within 60 years (Morse & McDonald creeks)	26 (Morse & McDonald Ck)

[6] Native summer-run in the Elwha River basin may no longer be present. Further work is needed to distinguish whether existing feral summer-run steelhead are derived from introduced Skamania Hatchery (Columbia River) summer run.

Hood Canal and Strait of Juan de Fuca MPG

The Hood Canal and Strait of Juan de Fuca MPG has eight DIPs including two summer/winter, and six winter DIPs (Table 7; Figure 5). Larger rivers share a common headwater source in the Olympic Mountain Range and are largely snowfield and/or glacially influenced. Most of these systems are dominated by relatively constrained high gradient reaches. In addition, there are numerous small tributaries, and those draining lowland areas are rain-dominated or rely on ground water (Myers et al. 2015). This MPG currently accounts for 12 percent of the steelhead abundance in the DPS (NWFSC 2015), based on available data. Steelhead abundance appears to be very low and relatively similar among the populations (Table 7), with the Dungeness and Skokomish DIPs comprising the majority of steelhead in the MPG.

Table 7. Abundance and trend information for DIPs within the Hood Canal and Strait of Juan de Fuca MPG for which information is available.

Population (Run Timing)	2005-2009 Geometric Mean Escapement (Spawners)[1]	2010-2014 Geometric Mean Escapement (Spawners)[1]	Percent Change[1]
Dungeness R SWR	**>100[2]**	**743[3,4]**	**NA**
East Hood Canal WR	62	60	-3%
Elwha R SWR	>100[2]	>100	
Sequim/Discovery Bay WR[5]	17	19	12%
Skokomish R WR	351	580	65%
S. Hood Canal Tribs WR	113	64	-43%
Strait of Juan de Fuca WR[6]	244	147	-40%
West Hood Canal WR	149	74	-50%

Sources: NWFSC 2015[1]; Hard et al. 2015[2]; C. Burns, Jamestown S'Klallam Tribe, and M. Haggerty, Haggerty Consulting, unpublished draft escapement estimates, February 2016 [3]

[4]Reported as 141 in NWFSC 2015. However, the NWFSC abundance estimates for the Dungeness River assumed that index area redd counts equated to individual steelhead escapement abundances. The natural steelhead abundance estimates reported in NWFSC (2015) are therefore minimal estimates (or underestimates) of actual natural steelhead escapement abundances (for years after 1996). To account for individual steelhead numbers, the index area redd count-based estimates reported in NWFSC (2015) have been expanded by the percent of the total available spawning habitat encompassed by the index area, survey timing and redd construction curves, and an average fish per redd. All estimates from 1999-2015 were expanded using identical methods which were at least in part based on methods used to generate estimates from 1988 through 1996 (see Figure 6).

[5]Snow Creek only

[6]Morse and McDonald creeks only

In the 2010 five year status review, NMFS found that the MPG showed a negative long-term growth rate of 1.3% per year (Ford et al. 2011). One natural population in this MPG was found to have a long-term positive growth rate (west Hood Canal) (Ford et al. 2011). In the 2015 status review, long-term (1999 through 2014) trends were evaluated for three DIPs within the MPG, and all were found to be negative (NWFSC 2015). Between the two most recent five-year periods (2004-2009 and 2010-2014), the geometric mean of estimated abundance for six DIPs were found to have increased by an average of 4.5% in the Hood Canal and Strait of Juan de Fuca MPG (NWFSC 2015). This percent increase in abundance within the MPG reported in NWFSC (2015) may be underestimated, as trends derived for years for which data are actually available for individual stocks grouped within several DIPs indicate substantially higher mean abundance increases between the two five year periods (e.g., for Morse Creek and McDonald Creek within the Strait of Juan de Fuca Independent DIP). Risk assessment by the PSSTRT indicated five steelhead populations within the MPG are at high risk of extinction, including the Dungeness DIP, and two are at low risk (Table 6; Table 7).

Dungeness River population

The PSSTRT delineated one extant steelhead population that is native to the Dungeness River watershed and part of the listed Puget Sound steelhead DPS: Dungeness River Winter-Run (Myers et al. 2015). A summer-run component of the steelhead return to the Dungeness River is thought to have existed historically in the upper accessible reaches of the mainstem Dungeness River and Gray Wolf River (Haring 1999), but it is uncertain whether the race still persists in the watershed. In a recent evaluation of Washington steelhead populations, WDFW listed the summer-run race in the Dungeness River as still extant (Scott and Gill 2008). Further monitoring is needed to establish whether native summer-run fish are still present and if they are part of a combined summer/winter natural population or represent an independent population (Myers et al. 2015). Steelhead recovery viability criteria recommend that at least one winter-run and one summer-run population of the six populations in the Hood Canal and Strait of Juan de Fuca MPG need to be restored to a low extinction risk status for recovery and delisting of the DPS (Hard et al. 2015). Hatchery-origin steelhead released from Dungeness River Hatchery are not included as part of the listed DPS (Jones 2011).

The majority of the Dungeness River winter-run steelhead population includes fish spawning in the mainstem Dungeness and Gray Wolf rivers (Myers et al. 2015). The extent of spawning is confined to areas downstream of naturally impassable barriers. Dungeness winter steelhead spawning distribution extends from the Dungeness River mainstem at RM 18.7, downstream to the upper extent of tidewater (Haring 1999). Winter steelhead distribution is assumed to also include the Bell, Gierin, Cassalery, Cooper, Meadowbrook, Matriotti, Beebe, Lotsgazell, Woodcock, Mud, Bear, Hurd, Bear, Canyon, and Gold Creek subbasins.

Adult winter-run steelhead enter the river on their spawning migration from November to early June. Spawning occurs from March through June, with peak spawning in May (Myers et al. 2015). Although age at spawning data are lacking for the Dungeness population, most natural-origin winter-run steelhead in Puget Sound return to spawn as four year-old fish, with five year-olds comprising a significant proportion of total returns (Myers et al. 2015, citing WDFW 1994). WDFW juvenile out-migrant trapping data from the 2005 through 2007 migration years indicate that natural-origin Dungeness River basin steelhead juveniles emigrate seaward as smolts between February and early July, with peak migration during the first two weeks of May (Topping et al. 2006; Topping and Kishimoto 2008; Topping et al. 2008). Steelhead smolt individual sizes observed in the WDFW the trapping study ranged from 85-mm to 290-mm fork length (fl), and averaged 170 mm (fl).

In the 1940s, winter-run steelhead fishing in the Dungeness River was considered among the best in Washington State (Myers et al. 2015). In 1903, during its second year of operation, the Dungeness Hatchery produced 3,100,840 steelhead fry or fingerlings, representing egg contribution from approximately 2,200 females; assuming a 1:1 sex ratio, the total return that year to the river could have exceeded 4,400 steelhead. Because of turbid water conditions in the Dungeness River during the months that steelhead return to spawn, there was no measure of adult returns until catch records became available. As a surrogate indicator of relative abundance, annual catch estimates based on adjusted catch record card returns from sport harvest averaged 348 steelhead from 1946 to 1953. These estimates of adult returns were prior to the introduction of “large numbers of hatchery fish” released as smolts (Myers et al. 2015). Natural-origin winter-run steelhead escapement estimates for return years 2009/10, 2010/2011, 2012/2013, 2013/2014, and 2014/15 averaged 750 fish; ranging from 484 fish (2009/2010) to 1,001 fish (2012/2013) (C. Burns, Jamestown S'Klallam Tribe, and M. Haggerty, Haggerty Consulting, unpublished draft escapement estimates, February 2016). Dungeness River steelhead spawning escapement estimates are available for 17 years over the period 1988 through 2015 (Figure 6).

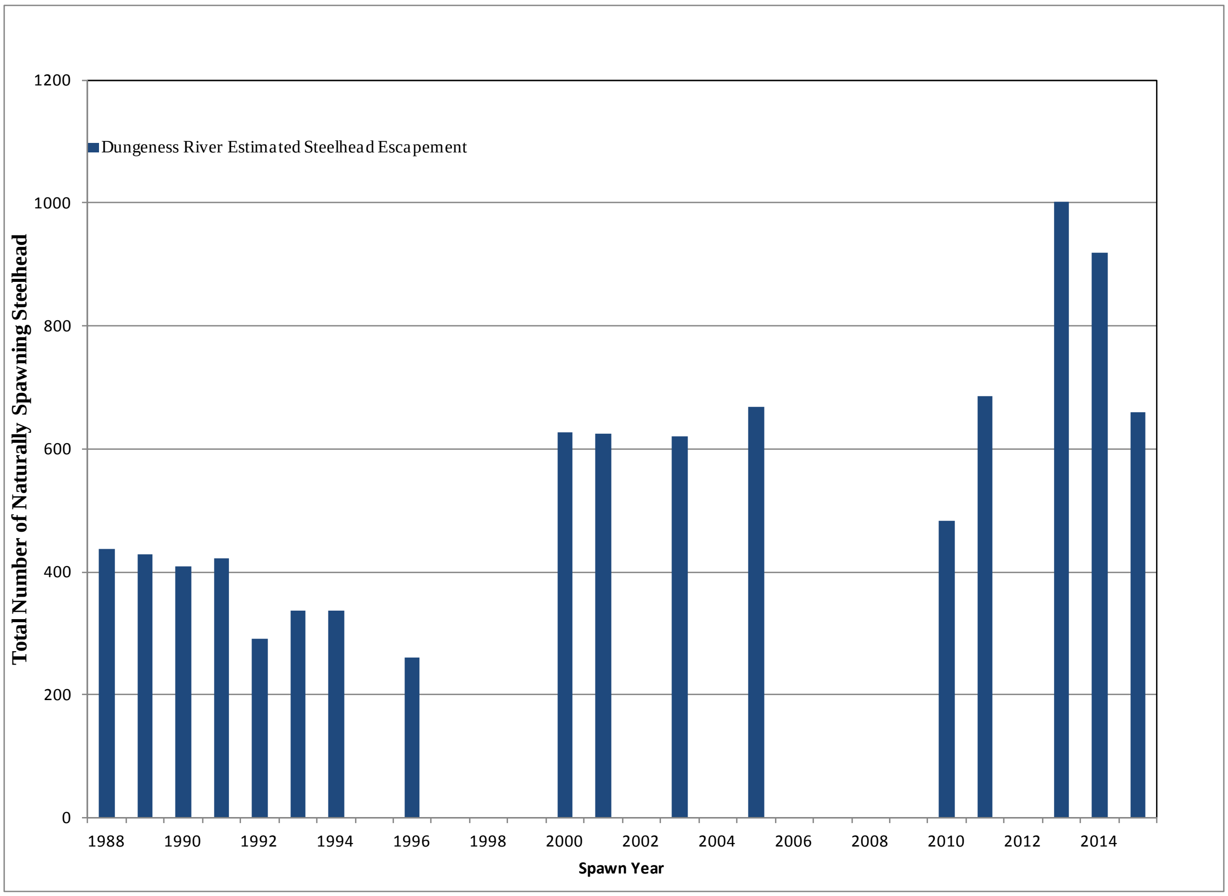

Figure 6. Dungeness River expanded estimated number of naturally spawning steelhead (natural-origin and hatchery-origin combined). source: 1988 - 1996 WDFW Score Database (note the 1996 estimate is unexpanded and based on a raw redd count of 162); 2000-2005 expanded estimates from WDFW spawning ground survey database; 2010-2015 C. Burns, Jamestown S'Klallam Tribe, and M. Haggerty, Haggerty Consulting, unpublished draft escapement estimates, February 2016.

An estimate of the intrinsic potential based on spawner capacity indicates that the Dungeness River watershed could support the production of 2,465 natural-origin steelhead, or 24,650 smolts (Myers et al. 2015). Smolt production from 2005 through 2014 has ranged from 5,521

(2012) to 19,600 (2011), averaging 12,717 (Figure 7). Current smolt production is approximately 52-percent of the intrinsic potential estimated by Myers et al. 2015. The critical threshold for winter-run steelhead natural spawners identified by the co-managers' is 125 fish and the viable threshold, reflecting a level of population abundance associated with a very high probability of persistence, or conversely, a very low risk of extinction, for a period of 100 years, is between 500 and 750 natural-origin spawners (PSIT and WDFW 2010b)

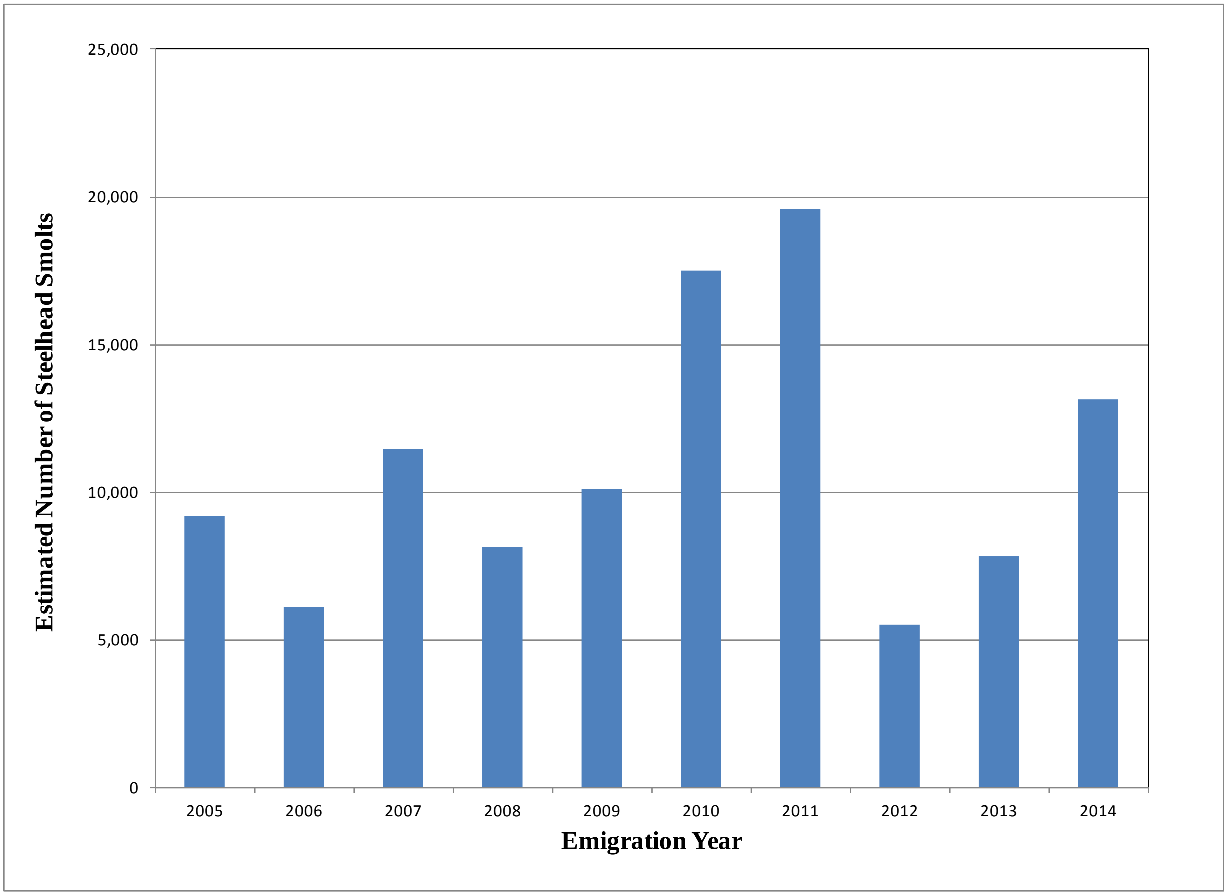

Figure 7. Dungeness River basin annual natural-origin steelhead smolt production.
Source: http://wdfw.wa.gov/conservation/research/projects/puget_sound_salmonids/dungeness/index.html

In a recent review by the PSTRT, productivity for the Dungeness DIP was considered to be declining, and the estimated probability that the Dungeness River winter-run steelhead population would decline to 10% of its current fish abundance, within 100 years was determined to be very high (Hard et al. 2015) (Table 7). However, this analysis does not account for steelhead escapements after 2001, and incorporates unexpanded redd counts for 1996 (expands for 1.62 steelhead per redd) and raw redd counts for 2000 and 2001. For example, for spawn year 2001, the model input used by Myers et al. (2015) is the raw steelhead redd count observed after March 15, estimated at 183 redds. Based on best available scientific information, the actual expanded redd count for the index reaches was estimated to be 323 (201 redds observed in index reaches). When the estimate of 323 redds is expanded for supplemental and unsurveyed river and tributary reaches, 386 steelhead redds would be estimated to have been created in the watershed in 2001. Expanding this total watershed redd count by 1.62 steelhead adults per redd yields as estimated spawner escapement of 626 fish in 2001.

Limited information on both spawning escapements and juvenile production preclude accurate serial estimates of productivity. Annual steelhead smolt productivity appears to be trending upwards based on the short-term annual observations (Hard et al. 2015; Figure 7).

Spatial structure of the winter-run steelhead natural population has been reduced by habitat loss and degradation in the Dungeness River watershed. Dikes, levees and other actions to control the lower reaches of the river and tributaries have reduced natural population spatial structure, particularly through adverse impacts on side channel habitat and increased scour of redds (Haring 1999). These actions have degraded available spawning and migration areas for adult fish, and refugia for rearing juvenile steelhead. Water withdrawals for irrigation and residential use have substantially reduced flows needed during the adult steelhead upstream migration and spawning periods, forcing adults to construct spawning redds in channel areas that are extremely susceptible to sediment scour and aggradation. Due to their late-winter and spring adult migration timing, spatial structure for the extant winter-run steelhead population was not thought to have been affected by seasonal operation of the Dungeness River Hatchery weir from the 1930s through the 1980s. Summer-run steelhead, if they still existed (Myers et al. 2015), may have been adversely affected by the weir when it was in operation over that period through migration delay and blockage.

Available data indicate that steelhead diversity in the Dungeness River watershed has declined relative to historical levels. It is likely that the historically extant summer-run component of the steelhead return has declined to very low levels or has become extirpated (based on discussion in Myers et al. 2015). As with Chinook salmon in the watershed, degradation and loss of habitat in the watershed, and past harvest practices, have reduced the diversity of the species in general relative to historical levels. Releases of non-native EWS from Dungeness River Hatchery have likely reduced genetic diversity of the native winter-run population in watershed areas where spawn timings for natural and hatchery-origin fish have over-lapped. However, there are no genetic data indicating that introgression associated with planting of the non-native stock has occurred (WDFW 2013a).

2.2.2.2. Status of Critical Habitat for Puget Sound Steelhead

Critical habitat for Puget Sound steelhead was designated on February 24, 2016 (81 FR 9252). Designated critical habitat for the Puget Sound steelhead DPS includes specific river reaches associated with 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. 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, unlike Puget Sound Chinook and Hood Canal summer chum, for which nearshore critical habitat areas were designated. Critical habitat also does not include offshore marine areas. There are 18 subbasins (HUC4 basins) containing 66 occupied watersheds (HUC5 basins) within the range of this DPS. Nine watersheds received a low conservation value rating, 16 received a medium rating, and 41 received a high rating to the DPS (78 FR 2726, January 14, 2013). Of the nine subbasins within the action area (Dungeness River, upper North Fork Nooksack, Middle Fork Nooksack, South Fork Nooksack, Lower North Fork Nooksack, Nooksack River, North Fork Stillaguamish, South Fork Stillaguamish, and Lower Stillaguamish River), seven received high and two medium (upper N.F. and M.F. Nooksack River) conservation value ratings (78 FR 2726, January 14, 2013).

NMFS determines the range-wide status of critical habitat by examining the condition of its physical and biological features (also called "primary constituent elements," or PCEs, in some designations) that were identified when the critical habitat was designated (81 FR 9252, February 24, 2016). These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). PCEs for Puget Sound steelhead, including the Dungeness population, include:

(1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development;

(2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

(3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival;

(4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

(5) Nearshore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.

(6) Offshore marine areas with water-quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The critical habitat for Puget Sound steelhead includes the Dungeness River within the action area and extends from the mouth of the Dungeness River upstream to the limits of steelhead access in the mainstem Dungeness River, Matriotti Creek, Bear Creek, Canyon Creek, Gold Creek, and the Gray Wolf River, and includes a lateral extent as defined by the ordinary high-water line (33 CFR 319.11). The Puget Sound Critical Habitat Analytical Review Team identified management activities that may affect the PCEs in the Dungeness Basin including irrigation impoundments/withdrawals, channel modifications/diking, sand/gravel mining, forestry, urbanization, and road building/maintenance (78 FR 2726, January 14, 2013; NMFS 2012a). The Puget Sound CHART found that habitat utilization by steelhead in a number of Puget Sound areas has been substantially affected by large dams and other manmade barriers in a number of drainages (this and following from NMFS 2013b). Affected areas include the Nooksack, Skagit, White, Nisqually, Skokomish, and Elwha river basins. In addition to limiting habitat accessibility, dams have affected steelhead habitat quality through changes in river hydrology, altered temperature profile, reduced downstream gravel recruitment, and the reduced recruitment of large woody debris. In addition, many upper tributaries in the Puget Sound region have been affected by poor forestry practices, while many of the lower reaches of rivers and their tributaries have been altered by agriculture and urban development. Urbanization has caused direct loss of riparian vegetation and soils, significantly altered hydrologic and erosional rates and processes (e.g., by creating impermeable surfaces such as roads, buildings, parking lots, sidewalks etc.), and polluted waterways with storm-water and point-source discharges. The loss of wetland and riparian habitat has dramatically changed the hydrology of many streams all to the detriment of steelhead habitat, with increases in flood frequency and peak flow during storm events and decreases in groundwater driven summer flows. River braiding and sinuosity have been reduced through the construction of dikes, hardening of banks with riprap, and channelization of the mainstem rivers. These actions have led to constriction of river flows, particularly during high flow events, increasing the likelihood of gravel scour and the dislocation of rearing juvenile steelhead. The loss of side-channel habitats has also reduced important areas for spawning, juvenile rearing, and overwintering habitats. Estuarine areas have been dredged and filled, resulting in the loss of important juvenile steelhead rearing areas.

2.2.3. Climate Change

Climate change has negative implications for designated critical habitats in the Pacific Northwest (CIG 2004; ISAB 2007; Scheuerell and Williams 2005; Zabel et al. 2006). This in turn is likely to affect the distribution and productivity of salmon populations in the region (Beechie 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). A warming of 0.1 ºC to 0.6 ºC per decade is projected for 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 stream-flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures. As climate change

progresses and stream temperatures warm, thermal refugia will be essential to persistence of many salmonid populations. Thermal refugia are important for providing salmon and steelhead with patches of suitable habitat while allowing them to undertake migrations through or to make foraging forays into areas with greater than optimal temperatures. To avoid waters above summer maximum temperatures, juvenile rearing may be increasingly found only in the confluence of colder tributaries or other areas of cold water refugia (Mantua et al. 2009).

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. For example, the Dungeness River is located in a rain shadow and as a result receives relatively little rainfall (the upper watershed receives approximately 63 inches of precipitation annually, but due to the "rainshadow" effect of the Olympic Mountains, Sequim receives only 16 inches). The Dungeness River is therefore particularly dependent on annual snow pack and is susceptible to habitat degradations that exacerbate low flow conditions. The Dungeness River typically undergoes two periods of high water and potential flooding in a year (USCOE 2015). The largest floods tend to occur between November and February, caused by high rainfall and snowmelt (Thomas et al. 1999). In years when winter rainfall is lower, the largest floods of the year occur in April through July, driven by higher temperatures and later snowmelt. Since climate change would likely reduce snowpack, run-off from snow melt in spring and summer would be reduced, and associated factors (e.g., re-channeling of the river bed, movement of silt out of the system, transport of woody debris) would be affected. “Reductions in stream flow [due to climate change] coupled with increased sediment delivery and a reduction in vegetative cover associated with [channel] braiding are likely to degrade salmon habitat over time” (USCOE 2015).

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).

Habitat preservation and restoration actions can help mitigate the adverse impacts of climate change on salmon. Examples include restoring connections to historical floodplains and freshwater and estuarine habitats to provide fish refugia and areas to store excess floodwaters, protecting and restoring riparian vegetation to ameliorate stream temperature increases, and purchasing or applying easements to lands that provide important cold water or refuge habitat (Battin et al. 2007; ISAB 2007). Harvest and hatchery actions can respond to changing conditions associated with climate change by incorporating greater uncertainty in assumptions about environmental conditions and conservative assumptions about salmon survival in setting management and program objectives and in determining rearing and release strategies (Beer and Anderson 2013).

2.3. Environmental Baseline

The “Environmental Baseline” includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

In order to understand what is affecting a species, it is first necessary to understand the biological requirements of the species. Each stage in a species' life-history has its own biological requirements (Groot and Margolis 1991; NRC 1996; Spence et al. 1996). Generally speaking, during spawning migrations, adult salmon require clean water with cool temperatures and access to thermal refugia, dissolved oxygen near 100 percent saturation, low turbidity, adequate flows and depths to allow passage over barriers to reach spawning sites, and sufficient holding and resting sites. Anadromous fish select spawning areas based on species-specific requirements of flow, water quality, substrate size, and groundwater upwelling. Embryo survival and fry emergence depend on substrate conditions (*e.g.*, gravel size, porosity, permeability, and oxygen concentrations), substrate stability during high flows, and, for most species, water temperatures of 13ºC or less. Habitat requirements for juvenile rearing include seasonally suitable microhabitats for holding, feeding, and resting. Migration of juveniles to rearing areas, whether the ocean, lakes, or other stream reaches, requires free access to these habitats.

A wide variety of human activities have affected listed Puget Sound steelhead and Puget Sound Chinook salmon, and Puget Sound Chinook salmon PCEs and proposed PCEs for steelhead, in the action area. These activities, more recently, include reclamation actions that are having beneficial effects. The Dungeness Basin is approximately 518 km^2 (200 $miles^2$) in area (Thomas et al. 1999), with its headwaters in the Olympic Mountains (Myers et al. 2015). Approximately 51,000 acres or 30 percent of the watershed is within the Olympic National Park (Table 8). In the lower 10 miles, the river flows through a broad valley before emptying

Table 8. Land use in the Dungeness River watershed[1] (Haring 1999).

Land Use	Acres	Percent of Area Watershed
Commercial Forestland	74,624	43.3
Residential High Density	1,364	0.8
Residential Low Density	5,940	3.4
Cropland	420	0.2
Pasture/Hayland	9,899	5.7
Grass/Scrub/Shrub	7,103	4.1
Private Woodlots	8,735	5.1
Conversions	2,377	1.4
Urban Lands	410	0.2
Ponds/River Channels	808	0.5
Quarries	167	0.1
Olympic National Park	51,308	29.7
Unclassified	9,362	5.4
Grand Total	**172,517**	

[1] The Dungeness "watershed" evaluated in Haring (1999) included the Dungeness River watershed, as well as several independent tributaries to the Strait of Juan de Fuca. These additional subbasins include: Gierin, Cassalery, Cooper, McDonald, Siebert, and Bagley Creeks.

into Dungeness Bay and the Strait of Juan de Fuca. The basin area includes over 546 miles of streams and tributaries and 33 miles of shoreline (SSPS 2005b). Geologically, the basin consists of volcanic bedrock and unstable glacial deposits that produce a high sediment load in surface flows (Haring 1999). The upper basin is glacially influenced and the flow regime in the Dungeness River is snowmelt dominated. Rainfall is the lowest of the Puget Sound basins (SSPS 2005b). Surface flows in the Dungeness River fluctuate seasonally.

In terms of resource extraction, commercial and private forestlands account for the majority of land use in the basin followed by rural and agricultural lands (21%) which dominate the floodplain (Table 8). Both the upper and lower watersheds have been logged over multiple generations. Formation of Olympic National Park protected headwater areas from logging but other sections of the upper watershed in the Olympic National Forest remain in commercial timber production. In these upstream areas, sediment input from unstable soils on steep slopes and forestry practices (particularly forest road management) have produced excessive sediments loads in the river (Haring 1999). These habitat impacts have led to river channel braiding and aggradation; disconnection of the river from its floodplain; blocking of access to productive side channel habitat; scouring of redds; and seasonal low flows that can severely impair salmonid stocks (Elwha-Dungeness Planning Unit 2005). Revised National Forest policies for timber management implemented in the upper watershed have become more protective of fish and wildlife species. The National Forest Service has targeted road remediation in the Dungeness River watershed to reduce the erosional and slope destabilization effects of logging road construction.

Dikes, bank armoring, and bridges confine the mainstem Dungeness River, disconnect off-channel habitat, reduce edge habitat complexity, and decrease channel stability. Beginning in the 1890s, extensive diking and conversion of historical estuary to agriculture and development lots has completely modified the Dungeness River estuary from its historical condition (this and following generally from Haring 1999 and SSPS 2005b). The marine nearshore habitat in Dungeness Bay has been affected by the alteration of sediment transport from the Dungeness River, by shoreline armoring, and by loss of eelgrass habitat (Haring 1999). Fish habitat in the lower 11 miles of the Dungeness River was further impacted by bank hardening to protect adjacent settled lands from erosion and flooding; clearing of riparian vegetation; gravel extractions; and operation of water diversions for irrigation purposes (Elwha-Dungeness Planning Unit 2005; Haring 1999). Dikes, levees and other actions to control the lower reaches of the river degraded rearing and migration areas for juvenile salmon. Tributaries truncated by these developmental activities harmed over-wintering habitat for coho salmon and steelhead, and contributed to scouring of redds (SSPS 2005a). Diking along the river constricted the natural process of stream channel formation and the transport of sediment. Major dikes are currently located on the east bank from RM 0 - 2.6 (the “Corps” dike) as well as RM 7.6 - 8.4 (the Dungeness Meadows dike)(SSPS 2005a). Smaller dikes and embankments constructed by private property owners are located throughout the lower ten miles of the mainstem river. Five bridges currently crossing the Dungeness River constrict the river, increasing water velocities and erosion potential to the detriment of salmon spawning, rearing, and migration conditions downstream (SSPS 2005a).

The Dungeness River is the river system most affected by irrigation withdrawals in western Washington (Haring 1999). Water rights were severely over-appropriated in a 1924 adjudication, and biologists measuring irrigation withdrawals in September of 1987 found that 82% of the total flow was being withdrawn (Clallam County and Jamestown S'Klallam Tribe 2005). The sources for this water are the Dungeness River and groundwater in its associated aquifer. Most of the water is diverted from the watershed for agricultural use through multiple water diversions (Figure 8) between mid-April and September, the same time that Chinook return to the river and begin to spawn. Chinook spawning success may be impaired in many years by these agricultural water diversions, particularly in late summer. Water withdrawals continue to affect salmon spawning and rearing habitat:

> "Water rights for irrigation and municipal purposes in the Dungeness River watershed greatly exceed summer low flows (540 cfs water rights vs. 173 cfs summer low flow) (Draft CIDMP, SDVAWUA, 8/29/03). Although these rights have never been fully utilized, in 1987 water users are estimated to have withdrawn 82% of the total river flow (~120 cfs) leaving ~25 cfs in the river (JSKT, 2003). Such a radical withdrawal of water virtually extinguished the ability of salmon to migrate upstream. In addition, spawning locations were limited to the mid-channel, where redds would be subjected to scour during winter storm events. In more recent years, water conservation measures undertaken by the irrigation districts, along with changing water needs, have dramatically reduced diversion rates. In 2001, 33% of the total river flow was diverted (~40 cfs), while ~95 cfs remained in the river (JSKT 2003).
>
> Even with these reduced diversions, water withdrawals continue to affect salmon spawning and rearing habitat. Two Incremental Flow Instream Methodology (IFIM) analyses on the Dungeness River show that during summer low flow conditions, each cfs of stream flow represents about 1% of the weighted usable area (WUA) of the river (USFWS 1991). In addition, recent work shows that side-channel habitat is very sensitive to flow (BOR and JSKT, 2003). In particular, this study found that in order to maintain conditions in most surface-fed side-channels suitable for spawning Chinook, the mainstem flow must exceed 180 cfs. When flows drop below 105 cfs, only one side-channel appears to meet spawning requirements for Chinook. Juvenile Chinook rearing habitat could be maintained in these side-channels at slightly reduced mainstem flows." − Clallam County and Jamestown S'Klallam Tribe (2005)[7]

[7]The references herein are verbatim and are not included in this document's reference list.

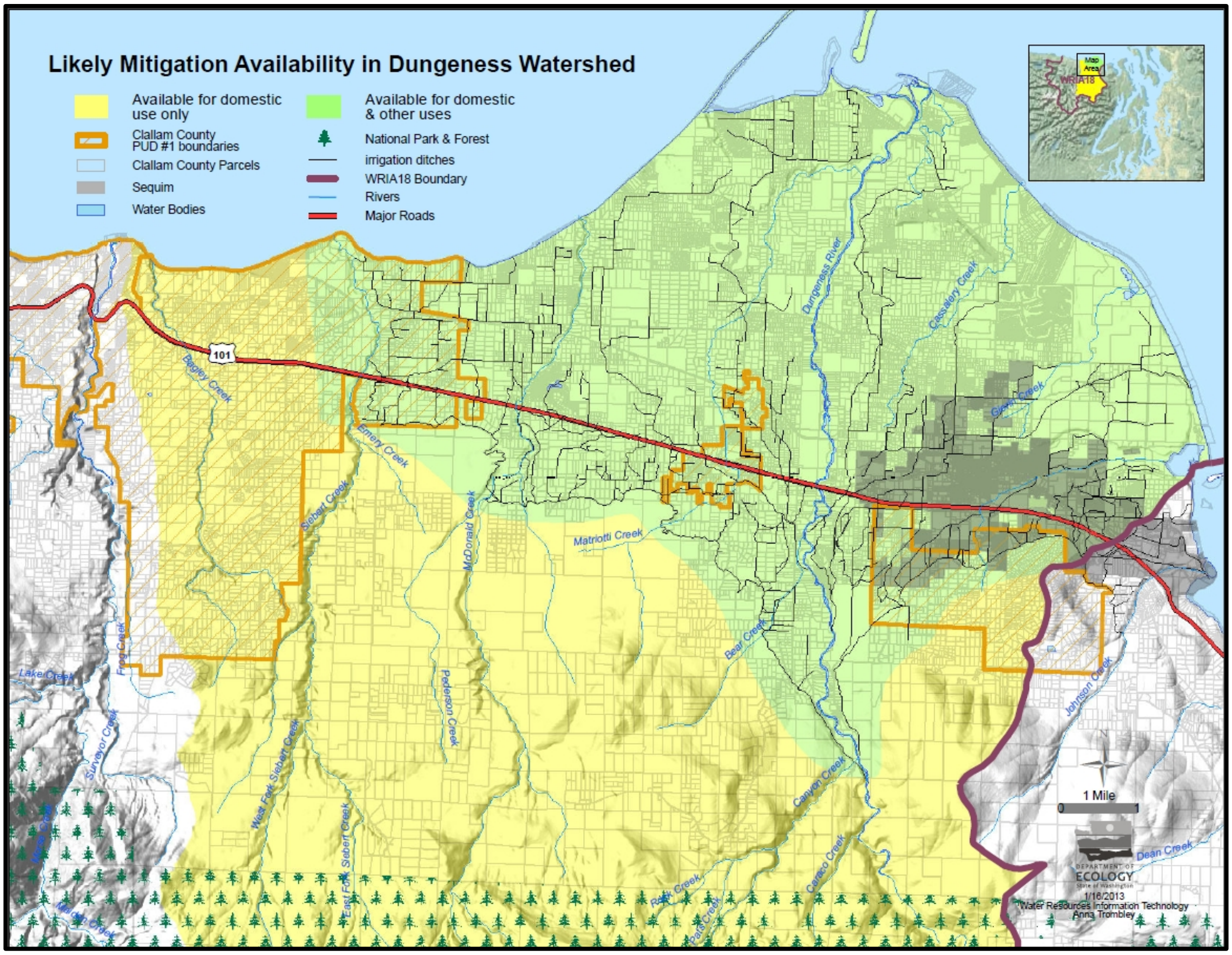

Figure 8. Irrigation water withdrawal locations and ditch systems within the Dungeness River Basin. Source: WDOE, 2014 - http://www.ecy.wa.gov/programs/wr/instream-flows/dungeness/dungeness-rule-map-avaliability.pdf

The above findings, reflecting substantial withdrawal effects on water quantity in the Dungeness River watershed for the period studied, are of concern because Clallam County population increased by over 76 percent between 1970 and 1992 and continues to grow today (SSPS 2005b). With the increasing human population in and around the city of Sequim, the demand for water for irrigation, domestic, and business use has markedly increased (SSPS 2005a). In addition, burgeoning human development in the watershed has added contaminated run-off from a variety of urban, agricultural, residential and other sources. All these activities adversely impact water quantity and quality. The Clallam Conservation District implemented major improvements in irrigation ditch systems to reduce or eliminate the addition of pollutants into the Dungeness River, tributaries and Dungeness Bay. Additionally, water temperatures in the Dungeness mainstem and side channels have improved by the reduction of diversions by the agricultural community (Clallam County and Jamestown S'Klallam 2005).

With continued growth in the region, threats to salmon and steelhead populations, and loss and degradation of their habitat will therefore persist. Areas along the main-stem river in some locations and along some lowland tributaries are most likely to be affected by growth and development pressures. When riverine lands are converted to residential and urban areas, forest cover and ecosystem processes are altered or lost and the change is almost always permanent.

2.3.1. Fisheries

There are no directed fisheries for natural-origin or hatchery-origin Chinook or fall-run pink salmon in the action area. Both species are propagated through the proposed hatchery programs for conservation purposes, and contribution to fisheries harvest is not an objective. As described by NMFS (2001; 2015), listed Hood Canal summer chum salmon, Puget Sound Chinook salmon, and steelhead are caught incidentally in fisheries targeting coho salmon and un-listed steelhead within the action area. Dungeness River summer chum salmon and Chinook salmon are also harvested incidentally in fisheries directed at more abundant salmon species in marine waters outside the action area. Under current harvest regimes, no directed fisheries occur for summer chum salmon, and total incidental fisheries impacts on Dungeness River summer chum salmon are limited to a "Base Conservation Rate" of 5% or less of the total population (WDFW and PNPTT 2000). This harvest level is considered sufficiently conservative to allow preservation and restoration of Dungeness River-origin summer chum salmon (NMFS 2001). To protect and recover the population to a viable status, as an objective, total harvest rates for Dungeness Chinook salmon in all Washington fisheries are managed to not exceed 10% of the total population. Between 2010 and 2012, the actual Washington (southern U.S.) harvest rate on Dungeness Chinook salmon ranged from 4% to 6%, and exploitation rates in 2015 Puget Sound salmon fisheries are expected to be less than 6% (NMFS 2011c). Total harvest rates remain high (40 to 41%) and above rebuilding exploitation rate objective (23%). Almost all of the harvest of Dungeness Chinook (85%) occurs in Canadian and Alaskan fisheries. Although the total harvest rate remains above desired levels, production from the conservation hatchery buffers demographic risks and preserves the genetic legacy of the population as degraded habitat is recovered. Including conservation hatchery production, escapement to the Dungeness River is expected to be above the critical abundance threshold level established to preserve the population (NMFS 2011d).

Although data are lacking for Dungeness River native steelhead, surrogate terminal steelhead harvest rates were calculated for a subset of Puget Sound watersheds for natural-origin steelhead and averaged 1.8 percent annually in Puget Sound fisheries during the 2007/2008 to 2013-2014 time period (NMFS 2011c). Given the similarity of recent freshwater fisheries and the predominance of hatchery fish in Puget Sound anticipated for the 2015-16 fishery season, the anticipated catch of hatchery-origin and natural-origin Puget Sound steelhead in freshwater treaty and non-treaty fisheries for the five representative populations is 1.8%. This proposed harvest rate is below the harvest rate estimate of 4.2 percent during the time of listing when NMFS determined that the current harvest management strategy that had eliminated direct harvest of natural-origin steelhead in Puget Sound had largely addressed the threat of decline to the listed DPS posed by harvest (72 FR 26722, May 11, 2007). In summary, and as mentioned in Section 1.3.2, NMFS analyzed the effects of all fisheries on listed Dungeness River watershed salmon and steelhead, and concluded that fisheries harvest actions within and outside of the action area are not likely to jeopardize the continued existence of the Hood Canal summer chum salmon ESU (NMFS 2001), or the Puget Sound Chinook salmon ESU and the Puget Sound Steelhead DPS (NMFS 2015), or adversely modify designated critical habitat for these listed species.

Within the action area, Jamestown S'Klallam tribal commercial and ceremonial and subsistence fisheries for Dungeness River watershed natural-origin and Dungeness River Hatchery-origin coho salmon occur seasonally in Dungeness Bay and the lower Dungeness River, contingent on the availability of natural-origin fish surplus to natural spawning escapement needs. A WDFW-managed non-Indian commercial skiff gillnet fishery in Dungeness Bay also targets returning coho salmon surplus to escapement needs. These tribal and WDFW net fisheries, as fully described in section 1.3.2, above, and previously considered by NMFS (2001), predominantly harvest hatchery-origin coho salmon produced by Dungeness River Hatchery (85% to 95% of fish encountered – S. Chitwood, Jamestown S'Klallam Tribe, pers. comm., August 5, 2013), but natural-origin coho salmon also contribute to annual harvests. Recreational fisheries for coho salmon managed by WDFW occur in the Dungeness River and Dungeness Bay. Between 2007 and 2011, annual tribal and non-Indian net fishery harvests of coho salmon in the analysis area averaged 759 natural-origin fish and 2,576 hatchery-origin fish (J. Haymes, WDFW unpublished data, January 7, 2013). Annual recreational fisheries harvests from 2007-2011 averaged 144 natural-origin coho salmon and 506 hatchery-origin fish. Total annual coho salmon harvests in the Dungeness River and Dungeness Bay fisheries from 2007-2011 averaged 3,905 fish, of which 84% were caught in commercial fisheries and 16% were caught in sport fisheries.

Annual tribal fisheries targeting non-listed hatchery steelhead in the Dungeness River action area, conducted for commercial, subsistence, and ceremonial purposes, are normally open for up to four-and-a-half days per week from the second week of December through February in Area 6D (Dungeness Bay) and in the Dungeness River. Tribal regulations permit use of nets and hook-and-line gear. Tribal fishing is excluded within a 1500-foot radius at the mouth of the Dungeness River as a measure to reduce impacts on milling/staging adult fish. The tribal hook-and-line subsistence fishery in the river is open from December through mid-March, under a daily bag limit of 2 fish. The recreational fishery in the Dungeness River is open from mid-October through January, from the mouth upstream to the Dungeness Forks Campground. Game fish regulations set a daily bag limit of two fish over 14 inches, composed of marked (hatchery-origin) steelhead, sea run cutthroat, or resident trout. The Gray Wolf River is closed to recreational fishing from November through early June. Annual tribal and recreational fishery harvests of mainly hatchery-origin winter-run steelhead in the analyses area from 1998 through 2008 averaged 15 fish (range 0 to 67 fish) and 54 fish (range 23 to 200 fish), respectively (PSIT and WDFW 2010b). Given measures designed to minimize impacts on wild steelhead, encounters with wild steelhead are much less frequent.

2.3.2. Hatcheries

Another important aspect of the Environmental Baseline is hatchery effects – effects from hatchery programs located in the Dungeness Basin (Section 2.4.2) and, potentially, from fish that stray into the Dungeness Basin from hatchery programs outside the basin (see below; for listed Chinook salmon, see Section 2.4.2.2). The Dungeness River Hatchery spring Chinook and fall-run pink salmon hatchery programs were initiated for integrated recovery purposes to conserve and restore the indigenous Chinook and fall-run pink salmon populations in the

Dungeness River. The coho salmon program at Dungeness River Hatchery operates for fisheries harvest augmentation purposes to partially mitigate for lost natural-origin coho salmon resulting from degradation and loss of habitat as a result of human developmental activities in the watershed. The Dungeness River Hatchery Chinook salmon program was initiated in its current form as a supplementation effort in 2004, after functioning as a captive broodstock-based program since 1992. The conservation program for fall-run pink salmon at the hatchery began in 2007. The Dungeness River Hatchery coho salmon program has operated for the longest duration, releasing smolts into the lower river since about 1902.

Past operation of the Chinook, fall-run pink, and coho salmon hatchery programs in the Dungeness River watershed may have affected the viability of listed natural-origin Chinook salmon and steelhead populations. The types of potential hatchery-related effects are identified in Section 2.4.1. Over its 11 years of operation, the Dungeness River Hatchery Chinook salmon program may have adversely affected the diversity, spatial structure, and productivity of the natural-origin population that is the subject of the conservation effort.

Collection of adult fish from the river and selection of fish for spawning may have inadvertently led to a situation where all extant families were not represented, potentially reducing within-population diversity of the propagated population relative to the naturally spawning aggregation. Creation of a captive population as a brood source may have further contributed within-population diversity loss. However, in creating the captive broodstock, best management practices were applied to eggs collected from redds to establish the captive broodstock were representative of the extant number of families, and to help ensure that the brood source would exhibit no genetic differences from the natural spawning population. The captive broodstock program was terminated in 2004, and the program was transitioned to a supplementation program. By limiting the length of the captive broodstock program (1992-1997 broods), the potential for adverse genetic effects on the listed natural fish resulting from selection in the hatchery were reduced. For the supplementation program, measures were implemented to collect and spawn adult fish representative of the run-at-large in terms of run timing, fish size, age class, and sex ratio may have reduced this genetic risk. Release of juvenile fish predominantly from Dungeness River Hatchery may have affected population spatial structure as a result of fish homing to and spawning near the lower river release location. Construction of smolt acclimation ponds in the upper watershed to enhance adult fish homing to upstream areas more suitable to natural spawning was designed reduced this risk. Propagation of Dungeness Chinook salmon in the hatchery may have reduced productivity of adult fish returning to spawn naturally relative to natural-origin fish (see Section 2.4.1.2). The Chinook salmon program may also have benefited the abundance of the Dungeness Chinook salmon population by increasing egg-to-emigrating smolt survival rates relative to naturally spawning Chinook salmon, considering the degraded state of natural fish habitat, which suppresses natural-origin fish productivity in the action area. The hatchery program for Chinook salmon has likely helped preserve the Dungeness Chinook population, and bolstered the population’s total abundance.

The three salmon hatchery programs, and a non-listed, early winter steelhead smolt release program operating at Dungeness River Hatchery (WDFW 2014), may have adversely affected listed Chinook salmon and steelhead through ecological effects. Included is predation on emigrating and rearing juvenile Chinook salmon by hatchery yearling Chinook and coho salmon, and steelhead in the lowest portion of the Dungeness River, downstream of Dungeness River Hatchery. The timing of hatchery yearling releases has coincided with the out-migration timing of natural-origin Chinook salmon of an average size vulnerable to predation. The magnitude of predation effects is unknown, but the practice of releasing migration-ready smolts into the lowest portions of the watershed limits the level and duration of interaction with juvenile natural-origin fish, which rear and migrate from areas throughout the watershed. Natural-origin juvenile steelhead of sizes vulnerable to predation by the hatchery yearlings emerge from upper river redds later in the season, and are unlikely to be encountered or preyed upon. Subyearling Chinook salmon produced through the Dungeness River Hatchery program have been released in May or June, after the majority of natural-origin Chinook salmon have emigrated seaward. No predation effects have likely occurred as a result of subyearling hatchery Chinook salmon releases. None of the hatchery-origin species produced in the action area are likely to compete with natural-origin Chinook salmon and steelhead at substantial levels for food or space. All of the hatchery salmon and steelhead are released as smolts that will quickly emigrate seaward, and are only released in the lower portion of the watershed. For these reasons, the duration of, and opportunities for, interactions that would lead to competition with listed juvenile fish have been limited.

Dungeness River hatchery facility operations may have adversely affected the viability status of natural-origin salmon and steelhead populations in the action area. A full river-spanning weir operated at the Dungeness River Hatchery at RM 10.8 beginning in the 1930s. The weir blocked Chinook salmon access to upstream spawning areas for approximately 50 years (SSPS 2005a). Although the weir was abandoned in the 1980s, its operation in prior years likely adversely affected the abundance and spatial structure of the natural-origin Dungeness Chinook population. Canyon Creek has been blocked by a diversion dam, to enable the withdrawal of water for use in the Dungeness Hatchery. Water is withdrawn from Canyon Creek only when withdrawal of water from the main source in the Dungeness River becomes infeasible due to icing and high flows during the winter months when flows are at their highest. WDFW reports that there is not enough water flow in Canyon Creek to use the intake in the creek during the summer and fall months when flows in Canyon Creek are at their lowest (Ward 2013). Recently, the WDFW proposed to construct a fish ladder to allow fish passage past that diversion dam. Consultation on the effects of the construction of the fish ladder has occurred (NMFS 2013b), with the work expected to be completed by 2017. The presence of the fish ladder is expected to open up access to several miles of Canyon Creek, some of which might be suitable habitat for salmonid spawning and rearing. During flood events, flow conditions will be rapid and complex and the fish ladder may not meet NMFS (2011b) fish passage criteria. However, upon completion of the project, fish should be able to ascend the project reach and access upstream areas at least 90% of the time (NMFS 2013b; USCOE 2012).

The effects of salmon and steelhead hatchery programs outside of the action area on Dungeness River Chinook salmon and steelhead are unknown but, for most hatchery-related factors, likely unsubstantial. The closest hatchery programs outside of the action area are located in the Elwha River. Juvenile and adult fish from the Elwha River are unlikely to interact with Dungeness River Chinook salmon and steelhead in the action area, and substantial ecological effects have been unlikely. The degree to which hatchery-origin salmon and steelhead adults originating from outside the action area stray into the Dungeness River watershed is unknown, and it is unknown if any straying occurs at levels that are different from stray rates exhibited naturally by Puget Sound salmon and steelhead populations. Currently, there are no data indicating the Elwha Chinook salmon or steelhead stray into the Dungeness River, and measures have been implemented to reduce the likelihood of fish from the Elwha programs entering the Dungeness River, including marking to allow for monitoring to determine the level of straying (NMFS 2014b). Among-population diversity reduction risks associated with out-of-basin hatchery salmon and steelhead straying into the Dungeness River would be essentially non-existent if assumptions of low levels of straying based on available information remain correct.

2.3.3. Other Restoration and Recovery Activities

The Pacific Coastal Salmon Recovery Fund (PCSRF) was established by Congress to help protect and recover salmon and steelhead populations and their habitats (NMFS 2007). The states of Washington, Oregon, California, Idaho, and Alaska, and the Puget Sound, Pacific Coastal and Columbia River tribes, receive PCSRF appropriations from NMFS each year. The fund supplements existing state, tribal and local programs to foster development of Federal-state-tribal-local partnerships in salmon and steelhead recovery. The PCSRF has made substantial progress in achieving program goals, as indicated in annual Reports to Congress, workshops, and independent reviews. Salmon and steelhead habitat restoration and protection projects in the Puget Sound region, including within the Dungeness River watershed action area, have been funded and implemented through the PCSRF process. For the Dungeness River watershed, salmon recovery projects proposed for funding through the PCSRF have been guided by plans prepared by the Dungeness River Restoration Work Group (DRRWG) and the Jamestown S'Klallam Tribe. The DRRWG prepared a habitat restoration plan, "Recommend Restoration Projects for the Dungeness River", which identified actions needed to address salmon habitat problems in the river on a reach-by-reach basis. The Jamestown S'Klallam Tribe's report "Restoring the Dungeness: An Overview of the Dungeness River Restoration Strategy" summarized recent habitat restoration work accomplished by the tribe and other local partners for salmon recovery purposes in the Dungeness watershed. The tribal plan included ten strategic habitat and restoration actions that would benefit listed Dungeness Chinook salmon recovery. Recent examples of habitat restoration and salmon recovery projects funded through the PCSRF and following these two plans that are expected to benefit listed Dungeness River Chinook salmon and steelhead population viability include:

- Construction by the Jamestown S'Klallam Tribe of 14 engineered logjams in three remote upper Dungeness River and Gray Wolf River reaches in the Olympic National Forest where habitat was severely damaged by historical projects that removed large wood. The logjams slow the river, creating places for salmon to rest, hide from predators, and feed, while helping to create pools where salmon can spawn.

- Improvement and stabilization of river banks on the lower Dungeness River by the North Olympic Salmon Coalition and Washington Conservation Corps through planting of trees and bushes along 75 acres of river bank, maintenance of existing plantings, and removal of invasive weeds on 112 acres of river channel.

- Restoration of the mouth of the Dungeness River and its associated flood flats through development of approved plans to set back dikes on both sides of the river's lower channel, restoring habitat along 1.8 miles of its length.

- Acquisition of land adjacent to the Dungeness River mouth and floodplain, encompassing essential habitat for salmon and steelhead rearing and migration.

- Replacement by to the Clallam Conservation District of approximately 2.8 miles of open irrigation ditch in the Dungeness River watershed for the purposes of conserving water withdrawn from surface and groundwater sources for irrigation purposes.

2.4. Effects on ESA Protected Species and on Designated Critical Habitat

The "effects of the action" means the direct and indirect effects of the action on the species and on designated critical habitat, together with the effects of other activities that are interrelated or interdependent, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

2.4.1. Factors That Are Considered When Analyzing Hatchery Effects

For Pacific salmon, NMFS evaluates extinction processes and effects of the proposed action beginning at the population scale (McElhany et al. 2000). NMFS defines population performance measures in terms of natural-origin fish and four key 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.

This section describes the methodology NMFS follows to analyze hatchery effects. The methodology is based on the best available scientific information. Analysis of the proposed action itself is described in Section 2.4.2 of the opinion.

Because of the potential for circumventing the high rates of early mortality typically experienced in the wild, artificial propagation may be useful in the recovery of listed salmon species. However, artificial propagation entails risks as well as opportunities for salmon conservation (Hard et al. 1992). A proposed action is analyzed for effects, positive and negative, on the attributes that define population viability, including abundance, productivity, diversity, and spatial structure. The effects of a hatchery program on the status of an ESU or steelhead DPS "will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery fish within the ESU affect each of the attributes" (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 also analyzes and takes into account the effects of hatchery facilities, for example, weirs and water diversions, on each VSP attribute and on designated critical habitat.

NMFS' analysis of the proposed action is in terms of effects it would be expected to have on ESA-listed species and on designated critical habitat based on the best scientific information on the general type of effect of that aspect of hatchery operation in the context of the specific application in the Dungeness River. This approach allows the clear quantification (wherever possible) of the various factors of hatchery operation to be applied to each applicable life-stage of affected listed species at the population level (in Section 2.4.2), which, in turn, allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (Section 2.6).

The effects, positive and negative, for two categories of hatchery programs are summarized in Table 9. Generally speaking, effects range from beneficial to negative for programs that use local fish[8] for hatchery broodstock and from negligible to negative when a program does not use local fish for broodstock[9]. Only integrated propagation programs can benefit population viability. Integrated hatchery programs use local fish for broodstock (natural-origin and hatchery-origin fish included in an ESU or DPS), follow "best management practices", and are designed around natural evolutionary processes that promote population viability (NMFS 2004b). When hatchery programs produce fish that are not intended to spawn naturally, such as those that use fish originating from a different population, MPG, or from a different ESU or DPS, NMFS is particularly interested in how effective the program will be at isolating hatchery fish and avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. The range in effects are refined and narrowed after available scientific information and the circumstances and conditions that are unique to individual hatchery programs are accounted for.

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.

NMFS analyzes seven factors for their effects on ESA-listed species. The seven factors are:

(1) broodstock collection,
(2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds,
(3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas,
(4) hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean,
(5) research, monitoring, and evaluation (RM&E),
(6) the operation, maintenance, and construction of hatchery facilities, and
(7) fisheries.

[8] The term "local fish" is defined to mean fish that are no more than moderately divergent from the associated local natural population. See 70 FR 37204, June 28, 2005.
[9] Exceptions include restoring extirpated populations and gene banks.

Table 9. Range in effects on natural population viability parameters from two categories of hatchery programs. The range in effects are refined and narrowed after the circumstances and conditions that are unique to individual hatchery programs are accounted for.

Natural population viability parameter	Hatchery broodstock originate from the local population and are included in the ESU or DPS	Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS
Productivity	**Positive to negative effect.** Hatcheries are unlikely to benefit productivity except in cases where the natural population's small size is, in itself, a predominant factor limiting population growth (i.e., productivity).	**Negligible to negative effect.** Effects dependent on differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (i.e., the greater the isolation the closer to a negligible effect).
Diversity	**Positive to negative effect.** Hatcheries can temporarily support natural populations that might otherwise be extirpated or suffer severe bottlenecks and they also have the potential to increase the effective size of small natural populations. Broodstock collection that homogenizes population structure is a threat to population diversity.	**Negligible to negative effect.** Effects 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.** Hatcheries can increase genetic resources to support recovery of an ESU or DPS in the wild. Using natural fish for broodstock can reduce abundance.	**Negligible to negative effect.** Effects dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation the closer to a negligible effect), and specific handling, RM&E, and facility operation, maintenance and construction actions.
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.	**Negligible to negative effect.** Effects dependent on facility operation, maintenance, and construction actions and the level of isolation achieved by the hatchery program (i.e., the greater the isolation the closer to a negligible effect).

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

(1) positive or beneficial effect on population viability;
(2) negligible effect—neither positive or negative—on population viability; and
(3) negative effect on population viability.

The category of effect assigned is based on an analysis of each factor weighed against:

- the affected population(s) current risk level for abundance, productivity, spatial structure, and diversity (low, moderate, high, or very high);

- the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery;
- the target viability status (highly viable, viable, or maintained) for the affected natural population(s); and,
- the factors limiting population viability.

2.4.1.1. Broodstock collection

Broodstock collection is arguably the single most important aspect of a hatchery program and it is a particularly important factor in the effects analysis. The first 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 consequences of using ESA-listed fish (natural or hatchery-origin). It considers the maximum number of fish proposed for collection, the proportion of the donor population tapped for broodstock, and whether the program "backfills" with fish from outside the local or immediate area. "Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure.

The analysis also considers the effects from encounters with ESA listed fish that are incidental to the conduct of broodstock collection. Here, NMFS analyzes the effects on ESA-listed fish when they encounter weirs, volunteer into fish ladders, or are subject to sorting and handling in the course of broodstock collection. Some programs collect their broodstock from fish volunteering into the hatchery itself, typically into a ladder and holding pond, while others sort through the run at large, usually at a weir, ladder, or sampling facility. Generally speaking, the more a hatchery program accesses the run at large for hatchery broodstock – that is, the more fish that are handled or delayed during migration – the greater the negative effect on 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.

2.4.1.2. Hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds

NMFS also analyzes the effects of hatchery returns and the progeny of naturally spawning hatchery fish on the spawning grounds. There are two aspects to this part of the analysis: genetic effects and ecological effects. NMFS generally views genetic effects as detrimental because at this time, based on the weight of available scientific information, we believe that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations. Hatchery fish thus pose a threat to natural population rebuilding and recovery when they interbreed with fish from natural populations. However, NMFS recognizes that there are benefits as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford 2011). Furthermore, NMFS also recognizes there is considerable uncertainty regarding genetic risk. The extent and duration of genetic change and fitness loss and the short and long-term implications and consequences for different species, for species with multiple life-history types, and for species subjected to different hatchery practices and protocols remains unclear and should be the subject of further scientific investigation. As a result, NMFS believes that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011d).

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 risk.

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

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

Inbreeding depression, another N_e-related phenomenon, is caused by the mating of closely related individuals (e.g., siblings, half-siblings, or cousins). The smaller the population, the more likely spawners will be related. Related individuals are likely to contain similar genetic material, and the resulting offspring may then have reduced survival because they are less variable genetically or have double doses of deleterious mutations. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.

Outbreeding effects are caused by gene flow from other populations. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993; Quinn 1997). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources. Hatchery programs can result in straying outside natural patterns for two reasons. First, hatchery fish may exhibit reduced homing fidelity relative to natural-origin fish (Goodman 2005; Grant 1997; Jonsson et al. 2003; Quinn 1997), resulting in unnatural levels of gene flow into recipient populations, either in terms of sources or rates. Second, even if hatchery fish home at the same level of fidelity as natural-origin fish, their higher abundance can cause unnatural straying levels into recipient populations. One goal for hatchery programs should be to ensure that hatchery practices do not lead to higher rates of genetic exchange with fish from natural populations than would occur naturally (Ryman 1991). Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997).

Gene flow from other populations can have two effects. It can increase genetic diversity (e.g., Ayllon et al. 2006) which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression (Figure 9).

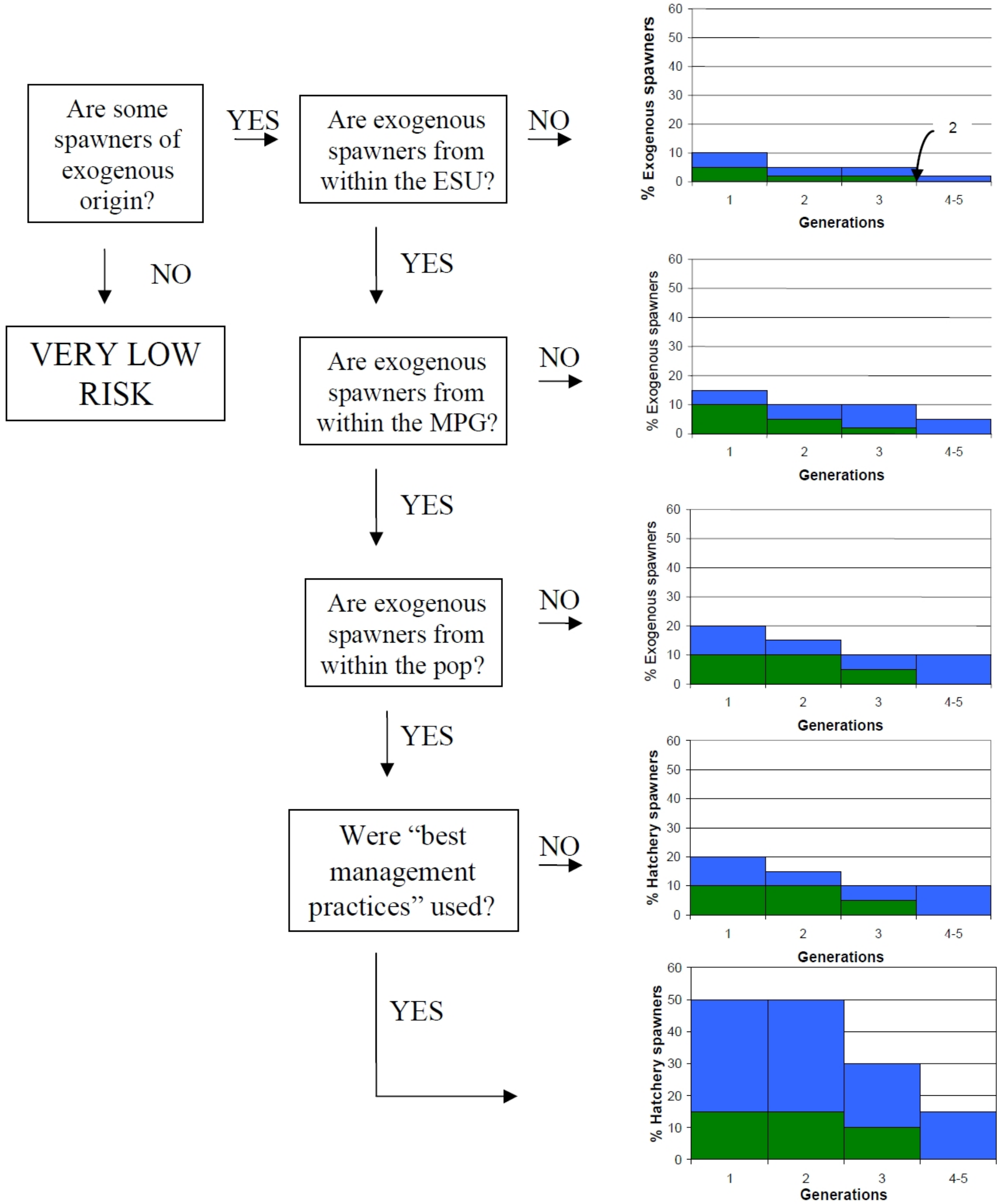

Figure 9. ICTRT (2007) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Green (darkest) areas indicate low risk combinations of duration and proportion of spawners, blue (intermediate areas indicate moderate risk areas and white areas and areas outside the graphed range indicate high risk. Exogenous fish are considered to be all fish hatchery-origin, and non-normative strays of natural-origin.

For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstocks. Additionally, unusual rates of straying into other populations within or beyond the population's MPG or ESU or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (e.g., Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

The proportion of hatchery fish among natural spawners, or "pHOS", is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze hatchery affects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before finally spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be applied 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; Warheit 2014). 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; McLean et al. 2004; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

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

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

Most of the empirical evidence of fitness depression due to hatchery-influenced selection comes from studies of species that are reared in the hatchery environment for an extended period – one to two years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and chum salmon is much shorter – just a few months. One especially well-publicized steelhead study (Araki et al. 2007; Araki et al. 2008), showed dramatic fitness declines in the progeny of naturally spawning Hood River hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies.

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery-origin and natural-origin fish (e.g., Berntson et al. 2011; Ford et al. 2012; Hess et al. 2012; Theriault et al. 2011). All have shown that generally hatchery-origin fish have lower reproductive success, though the differences have not always been statistically significant and in some years in some studies the opposite is true. Lowered reproductive success of hatchery-origin fish in these studies is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection, studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date only the Hood River steelhead (Araki et al. 2007; Christie et al. 2014) 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 interbreeding between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way.

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[10]. 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 9).

More recently, the Hatchery Scientific Review Group (HSRG) developed gene flow criteria/guidelines based on mathematical models developed by Ford (2002) and by Lynch and O'Hely (2001). Guidelines for segregated programs are based on pHOS, but guidelines for integrated programs are also based on a metric called proportionate natural influence (PNI), which is a function of pHOS and the proportion of natural-origin fish in the broodstock

[10] Gene flow between natural-origin and hatchery-origin fish is often, and quite reasonably, 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.

(pNOB)[11]. 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. For a population of high conservation importance their guidelines are a pHOS of no greater than 5% for segregated programs or a pHOS no greater than 30% and PNI of at least 67% for integrated programs (HSRG 2009). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk, in the short-term. HSRG (2004) offered additional guidance regarding segregated 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) in which they stated that the guidelines for segregated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

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 segregated 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 segregated, they recommend a pHOS of less than 5%. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity". They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50% in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5%, even approaching 100% at times. They also recommended for conservation programs that pNOB approach 100%, but pNOB levels should not be so high they pose demographic risk to the natural population (for example, from removing so many fish from the naturally spawning population that depensatory effects occur).

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

[11] PNI is computed as pNOB/(pNOB+pHOS). This statistic is really an approximation of the true proportionate natural influence (HSRG. 2009. Columbia River Hatchery Reform System-Wide Report. February 2009. Prepared by Hatchery Scientific Review Group. 278p.), but operationally the distinction is unimportant.

their Analytical Methods and Information Sources section (HSRG 2009, appendix C), they introduce a new term, *effective pHOS*. Despite these inconsistencies, their overall usage of pHOS indicates an intent to use pHOS as a surrogate measure of gene flow potential. This is demonstrated very well in the fitness effects appendix (HSRG 2009, appendix A1), in which pHOS is substituted for a gene flow variable in the equations used to develop the criteria. This confusion was cleared up in the 2014 update document (HSRG 2014), where it is clearly stated that the metric of interest is effective pHOS.

In the 2014 report, the HSRG explicitly addressed the differences between *census* pHOS and *effective* pHOS (HSRG 2014). In the document, the HSRG defined PNI as

$$PNI = \frac{pNOB}{(pNOB + pHOS_{eff})}$$

where $pHOS_{eff}$ is the effective proportion of hatchery fish in the naturally spawning population (HSRG 2014). The HSRG recognized that hatchery fish spawning naturally may on average produce fewer adult progeny than natural-origin spawners, as described above. To account for this difference, the HSRG defined *effective* pHOS as

$$pHOS_{eff} = RRS * pHOS_{census}$$

where $pHOS_{census}$ is the proportion of the naturally spawning population that is composed of hatchery-origin adults (HSRG 2014).

NMFS feels that adjustment of census pHOS by RRS should be done very cautiously, not nearly as freely as the HSRG document would suggest. The basic reason is quite simple: the Ford (2002) model, 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. An example of a case in which an adjustment by RRS might be justified is that of Wenatchee spring Chinook salmon (Williamson et al. 2010), 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 this, 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 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 gene flow data reflecting natural spawning effects of hatchery-origin fish are available, or an adjustment for RRS has strong justification, NMFS feels that census 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 10 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[12]. For example, the vertical line on the diagram marks the situation at a census pHOS level of 10%.

At this level, expectations are that 81% of the matings will be NxN, 18% will be NxH, and 1% will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10% will have an 81% chance of having two natural-origin parents, etc.

Random mating assumes that the natural-origin and hatchery-origin spawners overlap completely spatially and temporally. As overlap decreases, the proportion of NxH matings decreases and with no overlap the proportion of NxN matings is (1-pHOS) and the proportion of HxH matings is pHOS. RRS does not affect the mating type proportions directly, but changes their effective proportions. Overlap and RRS can be related. 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.

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

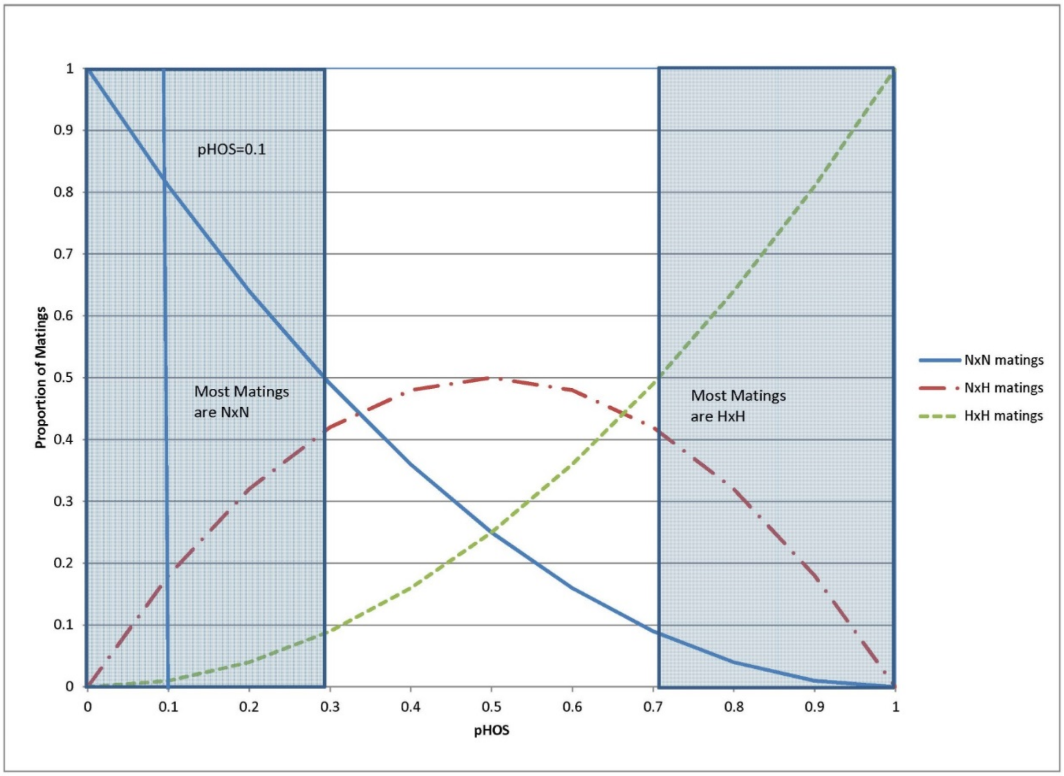

Figure 10. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS) (NxN – natural-origin x natural-origin; NxH – natural-origin x hatchery; HXH – hatchery x hatchery).

Ecological effects included under this factor (i.e., "[h]atchery 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 of hatchery fish on the spawning grounds may be positive or negative. In 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. 1998). 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; Quinn and Peterson 1996; Ward and Slaney 1988).

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

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

2.4.1.3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas

NMFS also analyzes the potential for competition, predation, and premature emigration when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas. Generally speaking, competition and a corresponding reduction in productivity and survival may result from *direct* interactions when hatchery-origin fish interfere with natural-origin fish accessibility to a resource that is limited, or through *indirect* interactions, when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (SIWG 1984). Naturally produced fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, when hatchery fish take up residency before naturally produced fry emerge from redds, and if hatchery fish residualize. Hatchery fish might alter naturally produced salmon behavioral patterns and habitat use, making them more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter naturally produced salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on naturally produced fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Specific hazards associated with competitive impacts of hatchery salmonids on listed naturally produced salmonids may include competition for food and rearing sites (NMFS 2012b). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (SIWG 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 a greater risk than interspecific competition, and competition would be expected to increase with prolonged freshwater co-occurrence. Although newly released hatchery smolts are commonly larger than natural-origin fish, and larger fish usually are superior competitors, natural-origin fish have the competitive advantage of prior residence when defending territories and resources in shared natural freshwater habitat. Tatara and Berejikian (2012) further reported that hatchery-induced developmental differences from co-occurring natural-origin fish life stages are variable and can favor both hatchery- and natural-origin fish. They concluded that of all factors, fish density of the composite population in relation to habitat carrying capacity likely exerts the greatest influence.

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

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a period of time in the vicinity of the release point. These non-migratory smolts (residuals) may directly compete for food and space with natural-origin juvenile salmonids of similar age. They also may prey on younger, smaller-sized juvenile salmonids. Although this behavior has been studied and observed most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well. Adverse impacts from residual Chinook and coho hatchery salmon on naturally produced salmonids are a possibility, given that the number of smolts per release from hatcheries in freshwater areas is generally higher for these species than for steelhead. However, the issue of residualism for hatchery Chinook and coho salmon has not been as widely investigated compared to steelhead. For all species, monitoring of natural stream areas downstream of hatchery release points is necessary to determine significance of hatchery smolt residualism on the natural-origin juvenile salmonids.

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

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990; California HSRG 2012).
- Operating hatcheries such that hatchery fish are reared to a sufficient and uniform individual size such that smoltification occurs in nearly the entire population (Bugert et al. 1992).
- Releasing hatchery smolts in lower river areas, below areas used by rearing naturally produced juveniles.

- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting hatchery rearing strategies, fish release location, and release timing if substantial competition with naturally rearing juveniles is documented.

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[13] including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

Another important possible ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (direct consumption) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Regarding direct predation, 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 more advanced life stage to emigrate quickly to the ocean (e.g., yearling smolts) can prey on fry and fingerlings of a vulnerable size that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream (residuals) where they can prey on stream-rearing juveniles over a more prolonged period. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance and when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility. Indirect predation effects associated with hatchery-origin fish and the progeny of naturally spawning hatchery fish include attraction of avian and other predators to an area because of an abundance of hatchery fish. However, en masse releases of hatchery fish may also “swamp” fish predators with an abundance of prey, leading to a reduction in predation rates on co-occurring natural-origin fish.

SIWG (1984) rated most risks associated with predation as unknown, because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead, and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1985; Hawkins and Tipping 1999; Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead timing and release protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already

[13] “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.

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, predominantly) 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 (SIWG 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 ½ 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 (Columbia Basin Fish and Wildlife Authority) 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 management actions that hatchery programs can implement to reduce or avoid the threat of predation:

- Adjusting the timing of hatchery fish releases to avoid the predominant seaward emigration periods for natural-origin salmon and steelhead populations, limiting interactions between the groups and the potential for 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

2.4.1.4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, in the estuary, and in the ocean

Based on a review of the scientific literature, NMFS' conclusion is that the influence of density-dependent interactions on the growth and survival of salmon and steelhead is likely small compared with the effects of large-scale and regional environmental conditions. While there is evidence that large-scale hatchery production can affect salmon survival at sea, the degree of effect or level of influence is not yet well understood or predictable. The same thing is true for mainstem rivers and estuaries. NMFS will remain informed regarding any new research that discerns and measures the frequency, intensity, and resulting effect of density-dependent interactions between hatchery and natural-origin fish. In the meantime, NMFS will monitor emerging science and information, and will re-initiate section 7 consultation in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4.1.5. Research, monitoring, and evaluation

NMFS also analyzes proposed RM&E actions for effects on listed species and on designated critical habitat. Generally speaking, negative effects on listed fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces critical uncertainties. RM&E actions including but not limited to collection and handling (purposeful or inadvertent), holding the fish in captivity, sampling (e.g., the removal of scales and tissues), tagging and fin clipping, and observation (in-water or from the bank) can cause harmful changes in behavior and reduced survival. These effects should not be confused with handling effects analyzed under broodstock collection. In addition, NMFS also considers the overall effectiveness of the RM&E program. There are five factors that NMFS takes into account when it assesses the beneficial and negative effects of hatchery RM&E: (1) the status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat, (2) critical uncertainties over effects of the proposed action on the species, (3) performance monitoring and determining the effectiveness of the hatchery program at achieving its goals and objectives, (4) identifying and quantifying collateral effects, and (5) tracking compliance of the hatchery program with the terms and conditions for implementing the program. After assessing the proposed hatchery RM&E and before it makes any recommendations to the action agencies, NMFS considers the benefit or usefulness of new or additional information, whether the desired information is available from another source, the effects on ESA-listed species, and cost.

Hatchery actions also must be assessed for masking effects. For these purposes, masking is when hatchery fish included in the proposed action mix with and cannot be differentiated from other fish. The effect of masking is that it undermines and confuses RM&E, and status and trends monitoring. Both adult and juvenile hatchery fish can have masking effects.

When presented with a proposed hatchery action, NMFS analyzes the nature and level of uncertainties caused by masking and whether and to what extent listed salmon and steelhead are at increased risk. The analysis also takes into account the role of the affected salmon and steelhead population(s) in recovery and whether unidentifiable hatchery fish compromise important RM&E.

2.4.1.6. The operation, maintenance, and construction of hatchery facilities

Operation, maintenance, and construction activities can alter fish behavior and can injure or kill eggs, juveniles and adults. They can also degrade habitat function. Within this effects category, NMFS analyzes a hatchery program for effects on listed species from encounters with hatchery structures and for effects on habitat conditions that support and promote viable salmonid populations. For example, NMFS wants to know if the survival or spatial structure of ESA-listed fish (adults and juveniles) are affected when the fish encounter weirs and other hatchery structures or by changes in the quantity or quality of stream flow caused by diversions. NMFS analyzes changes to riparian habitat, channel morphology and habitat complexity, and in-stream substrates attributable to operation, maintenance, and construction activities and confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria.

2.4.1.7. Fisheries

There are two aspects of fisheries that NMFS considers here. One is when listed species are inadvertently and incidentally taken in fisheries targeting hatchery fish, and the other is when fisheries are used as a tool to prevent hatchery fish, including hatchery fish included in an ESA listed ESU or DPS that are surplus to recovery needs, from spawning naturally. In each case, the fishery must be strictly regulated based on take levels, including catch and release effects, of natural-origin ESA-listed species.

2.4.2. Effects of the Proposed Action

Analysis of the proposed action identified two factors that may potentially have negative effects on ESA-protected Puget Sound Chinook salmon and/or Puget Sound steelhead and on designated critical habitat, and two factors that are likely to be beneficial to listed Puget Sound Chinook salmon. The proposed action would have a negligible effect on five other hatchery-related risk factors, and effects are not applicable for the remaining factors. A summarized analysis of all applicable (i.e., negative, beneficial, or negligible) hatchery effect factors is presented below (Table 10), followed by an expanded discussion of effects assigned for each applicable factor. The framework NMFS followed for analyzing effects of the proposed hatchery programs is described in Section 2.4.1 of this opinion.

Table 10. Summarized effects of the Dungeness River Hatchery salmon programs on Puget Sound Chinook salmon and Puget Sound steelhead and their designated critical habitat.

Factors	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
Broodstock collection when broodstock originate from the same ESU or DPS	Beneficial to negative effect	**Puget Sound Chinook salmon: Beneficial effect** Broodstock are adult natural- and hatchery-origin fish returning to the Dungeness River. Both components of the return represent the extant native stock and are part of the listed ESU. The hatchery program for the species operates for conservation purposes and benefits the abundance, diversity, and spatial structure of the depressed Dungeness Chinook salmon population. Best management practices are applied to help ensure broodstock collection, mating, rearing, and release practices do not lead to adverse genetic and ecological effects on the listed Dungeness Chinook salmon population. Broodstock collection activities targeting pink and coho salmon species would either occur at the same time and locations as collection actions planned for Chinook salmon, or at times and locations removed from natural Chinook salmon migration times and areas. **Puget Sound Steelhead: Negligible effect** The species is not collected as broodstock or propagated as part of the proposed action. Broodstock collection activities targeting salmon that would be propagated through the proposed programs occur well in advance of the mid to late winter adult native Dungeness steelhead migration and spawning periods, and no native steelhead are likely to be encountered.
Broodstock collection when broodstock originate from a different ESU or DPS	Negligible to negative effect	**Puget Sound Chinook salmon: Not applicable** There are no broodstock collected in the proposed Dungeness River Chinook Hatchery program originating from a different ESU. The native Dungeness Chinook salmon population is used as broodstock. **Puget Sound Steelhead: Not applicable** The species is not propagated as part of the proposed action, and no steelhead will be collected as broodstock.
Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds that are included in the same ESU or DPS	Beneficial to negative effect	**Puget Sound Chinook salmon:** **Genetic Diversity: Negative effect; Spawning Ground Competition/Redd Superimposition: Negative effect; Population Viability: Beneficial effect; Marine-derived Nutrients: Beneficial effect.** First or subsequent generation Chinook salmon adults produced through the hatchery program for the species have the potential to adversely affect the genetic diversity and fitness of the aggregate Dungeness population and of Chinook salmon populations in adjacent watersheds. Hatchery-origin pink salmon adults may spawn in the same areas where Dungeness Chinook salmon spawn, leading to adverse competitive and redd superimposition effects. The Chinook salmon program operates to preserve the Dungeness Chinook salmon population through supportive breeding. In

Factors	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
		addition to maintaining a listed population through supplementation, Chinook salmon produced through the hatchery program are intended to escape to natural spawning areas to help recover the abundance and spatial structure, and preserve the diversity of, the Dungeness Chinook salmon population. The program would likely benefit these viability parameters and recovery of the population by augmenting natural spawning abundances. Although the program would benefit the viability status of the population, the program may also pose risks to Dungeness Chinook salmon diversity and productivity that may result from natural spawning by hatchery-origin fish at high proportions of total abundance. The proposed pink and coho salmon programs would have negligible effects on listed Chinook salmon population viability. The carcasses of naturally spawning salmon and spawned broodstock originating from the three WDFW hatchery salmon programs would benefit listed Chinook salmon population productivity in the watershed by increasing the amount of marine derived nutrients. **Puget Sound Steelhead:** **Marine-derived Nutrients: Beneficial effect; Other factors: Not Applicable** The carcasses of naturally spawning salmon and spawned broodstock originating from the three WDFW hatchery salmon programs would benefit listed steelhead population productivity in the watershed by increasing the amount of marine derived nutrients. There would be no genetic diversity effects or effects on naturally spawning steelhead in spawning areas. The species is not propagated as part of the proposed action, and there would therefore be no adult hatchery steelhead produced that would stray into natural spawning areas. The earlier spawn timing for Chinook, pink, and coho salmon relative to steelhead makes adult fish interactions and substantial competitive or redd superimposition effects in listed steelhead spawning areas unlikely.
Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds that are not included in the same ESU or DPS	Negligible to negative effect	**Puget Sound Chinook salmon: Not applicable** There are no Chinook salmon propagated in the proposed Dungeness River Chinook Hatchery program originating from a different ESU that would escape to spawn in natural production areas. **Puget Sound Steelhead: Not applicable** The species is not propagated as part of the proposed action, and there would therefore be no adult hatchery steelhead produced that would stray into natural spawning areas.
Hatchery fish and the progeny of naturally spawning hatchery	Negligible to negative effect	**Puget Sound Chinook salmon and Puget Sound steelhead - Negligible to Negative effects** Interactions of concern in juvenile rearing areas are fish disease pathogen transfer and amplification; competition between

Factors	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
fish in juvenile rearing areas		hatchery-origin salmon and natural-origin Chinook salmon and steelhead for food and space; and hatchery fish predation on natural-origin fish. Proposed fish health protocols, and hatchery Chinook, pink, and coho salmon individual fish release sizes, timings and locations would minimize the magnitude and duration of any interactions with listed natural-origin Chinook salmon and steelhead that would lead to adverse effects from disease, competition, or predation. All fish would be released in healthy condition as seawater-ready, migrating smolts to ensure rapid emigration downstream through watershed areas where interactions with rearing listed fish may occur. Fish size, behavior, population individual size uniformity (goal CV of <10%), and morphology would be monitored at the hatchery rearing locations to assess readiness of the fish for release as smolts. BMPs included in the HGMPs and proposed for juvenile salmon rearing and release would reduce the risk of adverse ecological interaction effects (competition and predation) on listed natural-origin fish populations in the Dungeness River watershed, while promoting high juvenile fish to adult return survival rates consistent with meeting proposed program conservation or harvest augmentation objectives. *Fish Disease Pathogen Transfer and Amplification – Negligible effect* - The three HGMPs address general threats from fish disease pathogen transfer and amplification. The plans describe fish disease pathogen issues of concern and actions that would be implemented to minimize risks of disease pathogen transfer and amplification. All hatchery actions would be implemented in accordance with the "Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State (NWIFC and WDFW 2006). Protocols described in the policy and applied through the programs would help reduce risks of fish disease pathogens to propagated and natural fish populations through regular fish health monitoring and reporting, and application of best management practice measures to reduce fish health risks. *Competition – Negative effect* – After release, hatchery-origin Chinook and coho salmon may overlap spatially and temporally with natural-origin Chinook salmon and steelhead juveniles, potentially leading to competition for food and space for the period before the hatchery fish exit the Dungeness River seaward. To reduce the risk of spatial and temporal overlap between juvenile hatchery-origin and listed natural-origin fish that might lead to competition effects, the primary juvenile hatchery-origin fish release locations for the programs would be in the lower Dungeness River. The release of fish in the lower watershed would reduce the intensity and duration or interactions with natural-origin fish relative to releasing hatchery fish in upper portions of the watershed where natural-origin fish would primarily rear. All fish produced by the programs for release in the watershed would be released as seawater-ready fish (smolts or fry) as a measure to foster rapid emigration seaward, and clearance from watershed area

Factors	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
		where they may compete with natural-origin fish. The majority of juvenile fish produced through the Dungeness River Hatchery programs would be released after the majority of juvenile steelhead have emigrated seaward. The co-managers have included hatchery management measures in the proposed HGMPs that would adequately reduce substantial competition risks to listed fish from hatchery-origin salmon in the Dungeness River action area. *Predation – Negative effect* - The majority of juvenile salmon released through the hatchery programs are released at life stages and small individual sizes that would make predation on co-occurring natural-origin salmon and steelhead an unlikely event. The hatchery-origin species and life stages with substantial spatial and temporal overlap with juvenile listed Chinook salmon and steelhead of sizes vulnerable to predation would be yearling Chinook and coho salmon released from Dungeness River Hatchery and Hurd Creek Hatchery. The proposed programs for yearling Chinook and coho salmon would adequately reduce the potential for predation on listed juvenile salmon and steelhead through application of several risk reduction measures.
Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean	Negligible to negative effect	**Puget Sound Chinook salmon and Puget Sound steelhead - Negligible effect** Effects of the proposed action are not detectable. Available information does not show the level of hatchery production that leads to measureable ecological effects, including fish disease pathogen disease transfer, competition, and predation, nor does it identify how and to what extent listed species would be disadvantaged. The conditions under which any ecological interactions occur are unknown, and advantages and disadvantages for different fish origins, life-history stages, populations, ESUs, and DPSs are not detectable.

Factors	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
Hatchery research, monitoring, and evaluation	Beneficial to negative effect	**Puget Sound Chinook salmon and Puget Sound steelhead - Negligible effect** The primary monitoring and evaluation objective for the two conservation hatchery plans for Chinook salmon and pink salmon is assessment of the status of the target Dungeness River populations and the success of the programs in achieving restoration goals for the species. Monitoring and evaluation actions that would be implemented to determine whether this objective is met include spawning ground/redd surveys and hatchery escapement monitoring to determine total Chinook and pink salmon return abundances to the Dungeness River and the hatcheries. The number and distribution of tagged, untagged, and otolith marked fish escaping to the watershed each year would be monitored to determine the status of the natural- and hatchery-origin salmon returns relative to goal levels. In addition to regular foot surveys to census salmon spawning abundance, count redds, and sample carcasses to identify fish origin in natural spawning areas, adult fish abundance, origin, and distribution data would be collected through monitoring of weir counts at Dungeness River Hatchery and at the Dungeness River mainstem weir. Adult fish return abundance, timing, age class, sex ratio, and fish health condition data would be collected at the hatchery and weir collection locations to monitor the effects of the programs in increasing adult returns and maintaining the run traits of the target populations. Juvenile fish outmigrant data collected through annual operation of a downstream-migrant trap in the mainstem Dungeness River would allow for assessment of the natural spawning success of the salmon populations. The effects of these RM&E actions on listed Chinook salmon and steelhead are expected to be negligible.

Factors	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
Operation, maintenance, and construction of hatchery facilities	Beneficial to negative effect	**Puget Sound Chinook salmon and Puget Sound steelhead - Negative to negligible effect** No new construction is proposed through this consultation. There are three existing water intakes on Dungeness River and one on Canyon Creek supplying Dungeness River Hatchery that do not meet current NMFS "Anadromous Salmonid Passage Facility Design" criteria (WDFW 2013a; NMFS 2011b). The secondary water intake for Dungeness River Hatchery on Canyon Creek is adjacent to a small dam that completely blocks access to upstream salmon spawning habitat. WDFW is in the process of correcting fish passage problems at the location of the Dungeness River and Canyon Creek structures, with plans to complete work by fall 2019 and fall 2017, respectively. The current three structures used to withdraw water from the Dungeness River will be reduced to one structure, which will be passable to upstream and downstream migrating fish (WDFW 2013a). On Canyon Creek, by fall 2017, a ladder will be constructed in the dam that impounds water for periodic (winter only) use by the hatchery so that the structure is passable to migrating fish (WDFW 2013a: A. Carlson, WDFW, pers. comm., April 24, 2015). Through a separate NMFS ESA consultation (NMFS 2013b), effects of the construction of the fish ladder to allow unimpeded upstream and downstream passage for salmon, steelhead, and bull trout were found not likely to adversely affect ESA-listed salmon and steelhead. NMFS, through its approval, expects that the ladder as designed will allow the hatchery water intake structure on Canyon Creek to be brought into compliance with NMFS fish passage criteria (NMFS 2011b). WDFW plans to upgrade fish screens at Hurd Creek Hatchery to ensure compliance with NMFS fish passage criteria by summer 2017. However, a recent specific on-site evaluation of the Hurd Creek Hatchery surface water intake screen by WDFW presents information indicating adverse effects on any migrating salmonids are unlikely (Carlson and Williams 2015). Hatchery water intake and discharge screens protect juvenile fish from entrainment and injury and satisfy NMFS screen criteria. Operation of the hatchery programs is unlikely to degrade water quality. Water used at the primary fish rearing facility – Dungeness River Hatchery – is monitored, treated, and discharged in accordance with a current NPDES permit. Fish production at the other three rearing locations is too small to warrant effluent discharge limits. No hatchery maintenance activities are expected to adversely modify designated critical habitat.

Factors	Range in Potential Effects for this Factor	Analysis of Effects for each Factor
Fisheries	Beneficial to negative effect	**Puget Sound Chinook salmon and Puget Sound steelhead – Not Applicable** Fisheries are not proposed as part of the proposed action. NMFS's authorization for 'take' of ESA-listed fish associated with fisheries in Puget Sound and associated freshwater, including in the Dungeness River, is addressed annually or on a multi-year basis through a separate ESA section 7 consultation (most recently NMFS 2015a) on the current Puget Sound harvest plan assembled by the co-managers (most recently PSTT and WDFW 2015). Past effects of fisheries in the basin are discussed in the Environmental Baseline. Similar fisheries and effects are expected going forward.

2.4.2.1. Broodstock collection when broodstock originate from the same ESU or DPS

Beneficial effect – Genetic and Demographic Effects on Chinook salmon (Dungeness River Hatchery Chinook Salmon program)

The stated purpose of broodstock collection for the Dungeness River Hatchery Chinook Salmon program is to reestablish the native, at-risk Dungeness population for conservation purposes. The primary goal for the program is restoration of a viable, self-sustaining natural-origin Dungeness Chinook salmon population by using supportive breeding to preserve and restore the currently depressed native population.

As described in the HGMP (WDFW 2013a), the proposed hatchery Chinook salmon program takes into account the health, abundance, and trends for the ESA-listed Dungeness Chinook salmon population by serving as a supportive breeding program for a critically depressed natural-origin population. The program would incorporate natural-origin fish as broodstock to maintain the genetic diversity of the native population, and limit removal levels of returning adult fish from the natural environment as the status of the natural population improves. Broodstock are collected from indigenous-origin adults returning to Dungeness River. The average naturally spawning Chinook salmon adult escapement to the watershed in recent years (2000 through 2011) is 559 fish, which is only 46.6% of the recovery planning spawner abundance target for the population of 1,200 natural-origin fish, assuming a 2000-2009 productivity of 3.0 recruits per spawner[14]. Data for 2010 and 2011 indicate that the supportive breeding effort implemented as proposed in the HGMP is increasing the health and abundance of adult Chinook salmon returning to spawn naturally. Commensurate with larger releases of subyearling hatchery-origin fish, and improvements in hatchery subyearling and yearling release sizes and timings, naturally spawning adult returns in 2010 and 2011 were 345 and 535 fish, respectively. These naturally spawning return abundances compare with lower all

[14] Source for 1999-2009 productivity is Abundance and Productivity Tables from Puget Sound TRT database; measured as the mean of observed recruits/observed spawners over the 1999-2009 period. Source for Recovery Planning productivity target is the final NMFS Supplement to the Puget Sound Salmon Recovery Plan (NMFS 2006); measured as recruits/spawner associated with the number of spawners at Maximum Sustained Yield under recovered conditions.

natural-origin fish returns in previous years (2008: 140 fish; 2009: 128 fish) because no (brood year 2004), or substantially fewer (brood year 2005) subyearling or yearling smolt releases occurred through the program in the two primary contributing brood years (WDFW 2013a – Table 10.3.1). As a measure to limit divergence of the propagated population, broodstock are collected from the run at large at all trapping/capture sites in the Dungeness River. Natural-origin adults are incorporated as broodstock to help ensure that the hatchery and naturally-produced fish remain genetically similar, and as a further means to reduce the risk of genetic divergence between the hatchery and natural populations. To allow for their differentiation from natural-origin Chinook salmon, all hatchery-origin fish would receive a CWT, enabling detection and parsing of fish by origin during broodstock collection operations that would help meet genetic diversity preservation objectives.

Negligible effect – Other broodstock collection effects on all species (Dungeness River Hatchery Chinook, pink, and coho salmon programs)

Measures are applied that would adequately safeguard the health and abundance of listed salmon and steelhead in the Dungeness River that may be affected directly or incidentally by broodstock collection activities associated with the proposed Chinook, pink, and coho salmon hatchery programs. Coho salmon broodstock are collected as volunteers to the Dungeness River Hatchery trap during the adult return period for the species, and incidental effects on listed Chinook salmon and steelhead, which have different adult migration timings and that do not recruit to the hatchery trap are unlikely. In-river activities proposed to collect Chinook and pink salmon as broodstock (i.e., opportunistic seining, gillnetting, hook-and-line capture (including snagging), noodling, and operation of the mainstem river weir) would be confined to specific locations and periods to reduce the risk of adverse impacts on spawning Chinook salmon adults and their redds. Non-target listed fish are avoided in watershed areas outside of the hatcheries where Chinook and pink salmon broodstock are collected. Any listed Chinook salmon not needed as broodstock after the annual broodstock collection target for the hatchery conservation program has been met that are captured during broodstock collection actions targeting Chinook, pink, and coho salmon would be immediately released.

The annual target broodstock collection level is 112 adult Chinook salmon. In-river collection using the Game Farm weir is terminated after this target level is reached, which eliminates the risk of encounters with additional listed Chinook salmon during the adult return period. The adult Chinook, pink, and coho salmon return and spawning periods occur in the summer and fall months, and in advance of the period when native winter-run Dungeness River steelhead return to spawn (late winter and early spring). Although the Puget Sound TRT did not delineate a summer-run steelhead population in the Dungeness River (Myers et al. 2015), WDFW reported that a total of 21 adult steelhead of either natural- or hatchery-origin were trapped and released while collecting broodstock for Chinook salmon programs in 2011. These encounters with steelhead may have been due to operating the in-river broodstock collection programs earlier in the year than the start date proposed in the Chinook salmon hatchery plan (prior to May) (WDFW 2013a). Steelhead encountered during 2011 may possibly have been winter-run kelts leaving the Dungeness River for seawater, or summer-run fish that strayed as "dip-ins" into the river from other watersheds. Prior to 2011, no steelhead had been trapped during Chinook salmon broodstock collection operations for 5 years (WDFW 2013a). Any native stock steelhead captured during the proposed hatchery salmon broodstock collection actions would be immediately released.

Because of their relatively later return timing as adults, listed Dungeness River steelhead are unlikely to be encountered or affected during annual periods when in-river broodstock collection actions directed at Chinook and pink salmon would be implemented under the proposed hatchery programs. Broodstock collection actions for coho salmon will have no effect on steelhead because all coho salmon adults required as broodstock are collected as volunteers to the Dungeness River Hatchery trap, well removed from areas where steelhead may be present. The carcasses of pink salmon, and, secondarily, coho salmon, spawned for use as broodstock are distributed throughout accessible areas in the upper watershed as a means to benefit rearing natural-origin listed fish through nutrient enhancement.

2.4.2.2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds that are included in the same ESU or DPS

Negative effect (Genetic Diversity)

The Dungeness River Hatchery Chinook salmon program has the potential 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 the baseline diversity and productivity status of the Dungeness Chinook salmon population targeted for supportive breeding. Of concern regarding breeding between hatchery-origin and natural-origin Dungeness Chinook salmon are effects on the status of the natural population potentially resulting from within population diversity reduction and hatchery-induced selection.

Within-Population Diversity Reduction

The proposed Dungeness River Hatchery Chinook salmon supportive breeding program has the potential to reduce the genetic diversity of the target Dungeness Chinook salmon population. As background regarding this risk factor, WDFW endeavored to collect and include as many families as possible to establish the captive broodstocks originally used to found the hatchery Chinook salmon population (WDFW 2013a). To limit the risk of genetic diversity reduction, annual broodstock collection of adult fish returning to the river for the current supplementation program has been conducted with the goal of including a subset of the total adult run-at-large (in terms of return timing, sex ratio, age class, distribution) in the propagated population. The recent year (2000-2011) average total (hatchery- and natural-origin) adult return to the river is 653 fish (range 218 – 1,546 fish), with returns estimated at 457 fish and 681 fish in 2010 and 2011, respectively. The number of adult fish removed from the river for use as broodstock in the current program operating in 2010 and 2011 was 112 fish (25% of the 2010 adult return) and 146 fish (21% of the 2011 adult return), respectively (data from WDFW 2013a). Assuming the proportions of the total adult return collected as broodstock remain the same as in recent years, because only a subset of the total return is collected as broodstock, there is the potential that the program as proposed in the HGMP would not include a representative sample of the genetic diversity retained by the extant Dungeness Chinook salmon population. To reduce the threat of within-population diversity loss to the Dungeness Chinook salmon population, the Dungeness River Hatchery Chinook salmon program would implement the following risk reduction measures. The measures are designed to increase the likelihood that the program preserves, and does not reduce or substantially alter, the remaining genetic diversity of the natural population:

- To help ensure that broodstock collected for the program are representative of the total run-at-large each year:
    - Broodstock would be collected randomly throughout the entire adult Chinook salmon return period to the watershed.
    - The program would endeavor to ensure that run timing, location, age, and sex ratio of the Chinook salmon population collected as broodstock each year are reflective of the total adult return for each year with regards to run timing, return location, age class, and sex ratio.
    - Run timing, return location, age class, and sex ratio data would be collected annually from the total returns and from fish collected as broodstock to monitor whether hatchery broodstock are reflective of the run-at-large.
    - All female Chinook salmon collected through the mainstem weir, netting, gaffing, or as volunteers to the hatcheries would be used in the spawning operation, thereby reducing sources of bias that could lead to a non-representative sample of the broodstock.
- Otoliths would be collected from adult fish spawning naturally and fish retained as broodstock for analysis to determine the proportion hatchery-origin spawners and proportion natural-origin broodstock levels associated with the Chinook salmon program.
- Factorial mating strategies applied through the program help ensure that all fish collected have an equal opportunity to contribute to the production of progeny as a measure to retain the genetic diversity of the Chinook salmon population collected and spawned.
- All males collected, including jacks, would be included in spawning. If fewer gravid males than matured females are available on any spawning day, males would be live spawned, marked with an operculum punch, and returned to the hatchery holding pond for potential re-spawning. Such males would not be spawned more than twice.
- Fish surplus to hatchery needs will be released into the Dungeness River to allow the fish to spawn naturally, increasing the number of adult fish of the total population that would not be exposed to hatchery-related selection effects.

Hatchery-Induced Selection

First-generation hatchery-origin fish make up a very high proportion of the total adult return to the Dungeness River, and of fish collected as broodstock or spawning naturally in the river each year. Data from the WDFW HGMP (WDFW 2013a) indicate that from 2001 through 2011, the average proportion of hatchery-origin fish in the total naturally spawning Dungeness Chinook population was 71%, ranging from 39% to 96%. Although broodstock propagated through the program was originally founded through removal of eggs or fry from redds created by "wild" Chinook salmon, the practice of collecting broodstock from natural spawners ended after the 1997 brood year. Since that time, broodstock spawned have been captured from returns to the river or as volunteers to the hatchery. It is therefore highly likely that the proportion of hatchery-origin fish of the total spawned population is high and reflective of the proportion of hatchery-origin fish in the total annual return observed in recent years (averaging 71%). With these high proportions of hatchery-origin chinook salmon in the naturally spawning population and in hatchery broodstock, studies for other species in other watersheds suggest that there are high risks of hatchery-induced selection that could be associated with implementation of the Dungeness River Chinook salmon HGMP.

Although some progress has been made in preserving and restoring habitat critical for natural-origin Chinook salmon survival and productivity, actions to restore habitat have not kept pace with other components of the Chinook salmon recovery effort (WDFW 2013a), including those proposed in the program that have assisted in increasing adult returns. Habitat conditions continue to place all salmonid stocks at great risk. Considering the severely depressed abundance status of natural-origin Dungeness Chinook salmon returns, and very low productivity for fish migrating, spawning, and rearing in currently degraded habitat, the co-managers propose that the demographic risk faced by the natural population outweighs any hatchery-induced selection risks that would result from hatchery intervention as proposed in the Dungeness River Hatchery Chinook salmon HGMP. The conservation-directed program would preserve what remains of the Dungeness Chinook salmon population, and implement measures designed to retain extant genetic diversity until habitat is restored to properly functioning conditions.

The following genetic risk management measures are proposed in the HGMP to reduce the risk of intentional or unintentional hatchery-induced selection and biased sampling effects on Dungeness Chinook salmon population diversity (from WDFW 2013a):

- Broodstock used to sustain the program each year would be Dungeness Chinook salmon collected from the run-at-large adult return to the Dungeness River.
- Broodstock would be collected randomly across the breadth of the adult return timing, and representative of the age class distribution and sex ratio for the species, from the combined number of fish collected at the Dungeness River Hatchery trap, lower river mainstem river trap, and from the mainstem river through seining, gillnetting, noodling, or hook-and-line capture.
- In collecting adult Chinook salmon randomly from the total run-at-large in the mainstem river, natural-origin adults would be included as broodstock, which should assist in maintaining genetic similarity between fish propagated through the hatchery program and naturally-produced fish.
- In-river broodstock collection activities would be implemented in a manner that would protect naturally spawning Chinook salmon and their redds.
- The survival and diversity of the population collected and maintained for spawning until maturity would be enhanced by holding the fish in high quality well water.
- Mating protocols would be applied to reduce the risk of directed or unintentional selection of traits that could negatively affect the diversity of the population. These protocols would include:
    - Maximize representation of individual adult fish in the propagated population through use of all Chinook salmon, including jacks, collected randomly from broodstock retained for spawning.

    - Factorial 2x2 crosses would be the preferred method used for mating, but if necessary, other combinations can be utilized to maximize genotypic diversity. In 2x2 crosses eggs from two females would be split into two separate containers per female, milt from two males would be split into two separate containers per male, and eggs and milt would be mixed in all possible pairwise combinations.
- The majority of Chinook salmon (75%) produced through the Dungeness River Hatchery program would be subyearlings, reared for only a few months in the hatcheries. Limiting the duration of rearing in the hatchery by releasing Chinook salmon at the subyearling life-stage reduces the level of intervention into the natural salmonid life cycle, minimizing the potential for hatchery-induced selection.

Among-Population Diversity Reduction

The genetic diversity of the Dungeness Chinook salmon population could be adversely affected if the proposed hatchery program for the species incorporated as broodstock Chinook salmon originating from other Puget Sound populations. In addition, Dungeness River Hatchery-origin Chinook salmon may potentially stray into adjacent river basins in the Strait of Juan de Fuca region, and interbreed with other ESA listed Chinook salmon populations. Genetic diversity reduction to local “receiving” populations, and alterations in local adaptation resulting from any straying and interbreeding by Dungeness River Hatchery Chinook salmon are potential concerns.

The proposed Dungeness River Hatchery Chinook salmon program would be sustained only through the collection of broodstock from the adult salmon population returning to the Dungeness River (WDFW 2013a). The program is designed to preserve remaining diversity of a unique population of the species in the Dungeness River watershed, and would not increase the risk of outbreeding depression to the population by using an out-of-basin-origin Chinook salmon stock for propagation. All Chinook salmon released through the Dungeness River Hatchery program would be marked with a CWT, with unique watershed-specific tag numbers identifying their release strategy and location. Any Chinook salmon collected from the river that are adipose fin-clipped or that are unmarked but carrying a CWT from another hatchery program are culled and not used as broodstock. There are no data indicating that hatchery fish originating from other Puget Sound region hatcheries are straying into the Dungeness River. There have been no reported CWT recoveries of adult fish originating from the Dungeness River Hatchery program in the Elwha River, where the closest other independent Chinook salmon population occurs (WDFW 2013a). Available data for brood year 2000-2004 yearling releases indicate there was a single recovery of a hatchery-origin adult Dungeness Chinook salmon that strayed into another watershed in Puget Sound (WDFW 2013a) Located in the East Kitsap region, the watershed where the recovery was recorded lacks a unique Chinook salmon population that would potentially be affected by Dungeness River hatchery-origin Chinook salmon spawning. No other tag recoveries have been reported that would indicate Dungeness River Hatchery Chinook salmon straying into other Puget Sound watersheds. Although the risk of straying to other Chinook salmon watersheds appears to be very low, measures would still be implemented through the Dungeness River Hatchery program to limit the risks of straying and outbreeding depression resulting from production of returning adult hatchery-origin Chinook salmon:

- The proposed program would continue to propagate and release only fish from the local extant Dungeness Chinook population.
- Measures would be implemented at the time of spawning to avoid incorporation out-of-basin strays into the gene pool. Adults collected as broodstock would be checked for the presence of CWTs (all fish produced by the program are marked with a CWT only), and no fish with an adipose fin clip will be spawned.
- All juvenile fish released through the program would be marked with wire tags and/or otolith marks to allow for monitoring and evaluation of straying and natural spawning of Dungeness River hatchery-origin Chinook salmon in watersheds where adult fish may potentially stray.
- Straying into adjacent watersheds where other natural-origin Chinook salmon populations exist would be monitored through on-going mark and tag recovery programs implemented at hatchery broodstock collection sites and during spawning ground surveys.
- To reduce the risk of straying, juvenile fish reared through the program would be adequately acclimated to their sites of release in the Dungeness River to encourage a high return fidelity to those release sites when the fish return as adults.

Negative effect (Spawning ground competition and redd superimposition)

Hatchery-origin adult salmon produced through the three programs and escaping to spawn naturally have the potential to adversely affect listed Chinook salmon through competition for spawning sites and redd superimposition. The intent of the Dungeness River Hatchery Chinook salmon program is to produce native stock adult fish that will return to the Dungeness River to spawn naturally. The watershed is under-seeded with naturally spawning Chinook salmon (see Section 2.2.1), and competition for spawning sites with adult hatchery-origin Chinook salmon that are of the same listed population, and redd superimposition by hatchery Chinook salmon, are not concerns. Non-listed pink and coho salmon adults originating from the hatchery programs that escape to natural spawning areas may compete with Chinook salmon for spawning sites and superimpose Chinook salmon redds if the species overlap temporally and spatially (Table 11). Any effects associated with pink salmon spawning would be confined to odd-numbered years only, as there is no even-year pink salmon population in the Dungeness River.

Table 11. River entry timing, spawn timing, and spawning location for adult Chinook salmon, fall-run pink salmon, and coho salmon in the Dungeness River watershed.

Species	River Entry Timing	Spawn Timing	Spawning Locations
Chinook salmon	May 1 - August 15	August 15 – October 15	RM 0 to 18.9 in Dungeness River; RM 0 to 6.1 in Gray Wolf River
Pink salmon	September 1 – October 15	September 15 – October 24	RM 0 to 6.0 in Dungeness River
Coho salmon	September 15 – January 24	November 1 – January 24	Dungeness and Gray Wolf rivers and misc. tributaries

Data sources: WDFW (2002; 2013a; 2013b; 2013c)

Pink salmon adults spawning in the lowest 6 miles of the Dungeness River may spawn at times and in river areas where Chinook salmon spawning may occur. WDFW Chinook salmon redd count survey data for 2000 through 2013 indicate that 40% of the total number of redds created by naturally spawning Chinook salmon were observed in the lower 6.4 miles of the river (Section 15; M. Haggerty, Haggerty Consulting, and R. Cooper, WDFW, unpublished WDFW data, September 17, 2014). Applying this proportion to the 1999 through 2011 average total naturally spawning Chinook salmon abundance of 113 fish (Table 4), and assuming two Chinook salmon per redd under current run sizes and conditions, an estimated 23 Chinook salmon (approximately 12 pairs), would potentially be affected through competition with pink salmon for spawning space in odd-numbered years. The proposed hatchery program for pink salmon would produce 100,000 fry each year. Assuming a survival rate to adult return of 1.0% for hatchery-origin pink salmon fry releases (Fuss and Ashbrook 1995), the program may lead to the return of approximately 1,000 pink salmon adults. Although dominance of pink salmon over much larger-sized Chinook salmon adults for advantageous spawning areas is an unlikely event, mass spawning by pink salmon in areas where Chinook salmon are spawning could disrupt Chinook salmon redds to the detriment of Chinook salmon abundance and productivity (Fukushima et al. 1998). However, Chinook salmon excavate, and deposit their eggs into deeper redds on average than pink salmon (DeVries 1997), making detrimental redd superimposition by naturally spawning hatchery-origin pink salmon unlikely. Further, the two species prefer different gravel sizes for spawning, which fosters separation in redd locations, decreasing the potential for adverse species interactions. Kondolf and Wolman (1993) reported the median particle size for pink salmon redds was 9 mm and 35 mm for Chinook salmon. Also, the fall-run pink salmon produced through the Dungeness River Hatchery program for the species return and spawn in the lowest portion of the watershed used by the Dungeness Chinook salmon population, and the majority of Chinook salmon spawning areas would not be affected. Assuming all hatchery-origin adult pink salmon escape to natural areas, 1,000 pink salmon spawning across 6 miles of mainstem river habitat, returning only in odd-numbered years, are unlikely to substantially compete for spawning areas with any Chinook salmon present, or disrupt Chinook salmon redds. These data indicate that although the two species may overlap in migration and spawning times, potentially affecting redds created by 23 Chinook salmon, spawning likely occurs in substantially different locations within the river channel. Coho salmon originating from the Dungeness River Hatchery program spawn too late in the season to have any substantial effects on earlier spawning Chinook salmon or their redds (Table 11).

Beneficial effect (Population Viability)

The Dungeness River Hatchery Chinook salmon program would be implemented to benefit the viability status of the natural-origin Chinook salmon population in the Dungeness River. In an evaluation of hatchery effects associated with implementation of its Hatchery Listing Policy (70 FR 37204, June 28, 2005), NMFS determined that fish produced through certain artificial propagation programs in the Puget Sound region may benefit particular viability parameters (McElhany et al. 2000) for specific populations included within listed salmon ESUs (70 FR 37204. June 28, 2005). Hatchery-origin populations determined to be no more than moderately diverged from reference natural-origin populations in the watersheds where the hatchery-origin fish were released were determined to impart varying degrees of benefits to the abundance, diversity, and spatial structure of natural-origin salmon and steelhead populations. Chinook salmon that would be produced through the proposed Dungeness River Hatchery program (WDFW 2013a) are considered no more than moderately diverged from their associated natural-origin Dungeness population that served as donor broodstock for the program (70 FR 37160, June 28, 2005). The ESA-listed hatchery-origin fish produced by the WDFW program may therefore impart viability benefits to the natural-origin population that it was designed to support (Jones 2011).

Abundance

One main benefit potentially conferred by hatcheries is an increase in the natural abundance of a listed salmon population that emigrate seaward as smolts and return to spawn naturally in a particular watershed. Freshwater habitat-related factors limiting the survival and productivity of a natural population for certain critical life history phases can be circumvented by conducting spawning, incubation and rearing in the hatchery environment, and releasing seawater-ready smolts that are part of the population. A proportion of returning adult fish from the hatchery releases would spawn naturally, producing natural-origin progeny that would, in turn, return as adults to spawn naturally. Short term success in increasing the number of natural-origin, naturally spawning fish has been demonstrated for certain hatchery programs. Examples include Hood Canal summer chum salmon and reintroduction programs for Chimacum Creek (PNPTT and WDFW 2007; WDFW and PNPTT 2000); Lake Ozette sockeye salmon supplementation of Umbrella Creek (Makah Fisheries Management 2010); Hamma Hamma winter-run steelhead (Berejikian et al. 2008); and purposeful release of stray, mainly Issaquah Hatchery-origin Chinook salmon upstream of Landsburg Dam in the Cedar River (Anderson et al. 2012). However, natural populations that rely on artificial propagation are not viable (McElhany 2000) and success in increasing natural-origin fish abundance depends not on supportive breeding but on fixing or addressing limiting factors, including commensurate improvements in the condition and productivity of natural habitat (WDFW and PNPTT 2000; California HSRG 2012).

The Dungeness River Hatchery Chinook salmon program would be implemented to support the native Dungeness Chinook salmon population (WDFW 2013a). The program would provide a safety net for the native stock while essential habitat for the species is restored, and then improves to a state that would sustain natural-origin Chinook salmon survival and productivity. All fish produced by the hatchery program will be included with natural-origin Dungeness Chinook salmon as part of the Puget Sound Chinook salmon ESU listed under the ESA. Assuming annual production of 150,000 subyearlings and 50,000 yearlings, survival rates to adult return of 0.5% for subyearlings and 1.0% for yearlings (approximate realized rates for WDFW hatchery Chinook salmon from Fuss and Ashbrook 1995), and survival rates to escapement from Table 3.3.1.1 in WDFW (2013a) (see Table 11), the proposed program could potentially lead to the annual escapement of 892 adult Chinook salmon to the Dungeness River watershed. A maximum of 112 adult Chinook salmon would be required for use as broodstock each year to sustain the hatchery program (WDFW 2013a). The remainder of returning adult fish (at least 780 fish) would escape to spawn naturally.

From WDFW (2013a), the recent eleven-year (2001-2011) average number of Chinook salmon spawning naturally in the Dungeness River was 590 fish. Data reported by WDFW (2013a) indicate that 77% of the total number of fish spawning naturally over that period originated from the hatchery program. Estimated average annual natural and hatchery-origin Chinook salmon contributions to natural spawning in the watershed over this period were therefore 136 fish and 454 fish, respectively. As indicated above, the proposed hatchery program would potentially contribute at least 780 naturally spawning fish to the escapement each year. Assuming a continuation of natural-origin adult returns similar to the 2001-2011 average of 136 fish, the supportive breeding program proposed by WDFW would increase the number of naturally spawning Chinook salmon to 916 fish, representing an increase in escapement of 55% relative to the 2001-2011 average.

Because the native Dungeness Chinook salmon population would serve as broodstock, and because a substantial proportion of returning hatchery-origin fish would escape to spawn naturally, the program is expected to benefit natural population abundance by preserving the population while natural productivity conditions in the watershed remain degraded. As habitat conditions improve because of implementation of habitat protection and restoration actions, the supportive breeding program would substantially increase the abundance of Dungeness Chinook salmon, relative to current escapement levels.

Diversity

In addition to increasing the total number of returning adult salmon, hatcheries can also benefit population and ESU genetic diversity. Due to the poor status of natural-origin populations in a watershed, genetic resources important to an ESU may reside in a supportive breeding program that was developed using the natural-origin population as the donor. In 2005, NMFS determined that salmon and steelhead produced by all conservation hatchery programs and several harvest augmentation programs in the Puget Sound region should be included as part of the listed salmon ESUs and steelhead DPSs, as they served as genetic reserves and a brood source for rebuilding extant natural-origin salmon and steelhead populations residing in the watersheds (70 FR 37160; June 28, 2005). Among the hatchery Chinook salmon populations included as part of the listed Puget Sound Chinook salmon ESU are fish produced through the Dungeness River Hatchery program.

The proposed Dungeness River Hatchery Chinook salmon program would benefit the diversity of the native Dungeness Chinook salmon population by preserving and assisting in the restoration of the unique stock while habitat remains degraded, and as the habitat is restored. The supportive breeding program would preserve the population until prospects for its survival in the wild improve. In a past review of the effects of the WDFW hatchery program, the HSRG concluded “the short-term goals of maintaining the Dungeness chinook in protective custody, while maintaining genetic characteristics of the stock, in order to protect the stock from extinction, are likely being met” (HSRG 2002). Without this supportive breeding effort, the genetically unique Dungeness Chinook salmon population would be at high risk of extinction due to current critically low natural-origin fish abundance levels (under 200 adult fish per year) and threats to the remaining population returning to the river posed by degraded freshwater habitat. As a “Tier 1” population for ESU recovery (NMFS 2010), the loss of the Dungeness Chinook salmon genome, representing one of the two extant populations of the species remaining in the Strait of Juan de Fuca biogeographical region, would be a serious setback and likely prolong the recovery of the Puget Sound Chinook salmon ESU. Increased smolt emigration and adult fish returns afforded by the hatchery program over levels achievable under current natural conditions will help ensure that this unique population is retained to the point where local adaptation and creation of a self-sustaining population, without the need for supportive breeding, will be achieved.

Spatial Structure

Hatchery programs operating for supportive breeding purposes using native stocks can contribute an abundance of fish that spawn naturally. Through acclimation of fish to unused or under-seeded habitat, and through density dependent effects, such programs can expand salmon population spawning and rearing distribution within a watershed where spatial structure has been reduced relative to historical levels.

The proposed Dungeness River Hatchery Chinook salmon program would be operated as an integrated recovery program, benefiting spatial structure of the native Dungeness population. One objective is to return adult fish to the main Dungeness River Hatchery facility and at Hurd Creek Hatchery through on-station smolt releases to provide broodstock, and seed lower watershed areas with naturally spawning fish. The program also has the objective of producing adult returns that would disperse and spawn naturally in the upper Dungeness River and Gray Wolf River through operation of the Upper Dungeness River and Gray Wolf River acclimation ponds. Chinook salmon habitat in the upper Dungeness and Gray Wolf Rivers is under-seeded. Chinook salmon subyearlings would be reared and acclimated, and adult fish produced would return to the upper watershed release areas to spawn naturally. As noted previously, the current naturally produced Dungeness Chinook salmon population is depressed in abundance (under 200 fish), and of insufficient size to disperse into available habitat in the watershed. Release of hatchery Chinook salmon juveniles from the hatcheries and acclimation pond sites will benefit population spatial structure by fostering adult returns to under-seeded spawning areas throughout the watershed. For these reasons, the proposed Chinook salmon program will benefit Dungeness Chinook salmon population spatial structure above levels achievable through natural production only.

Productivity

Supportive breeding generally does not benefit natural salmon population productivity. Decades of straying by hatchery-origin fish in Puget Sound have not been observed to result in increases in the productivity of any natural-origin Puget Sound Chinook salmon populations (NMFS 2004c). Further, as detailed in section 2.4.1.2, the productivity of natural-origin salmonid populations may be impaired by spawning and genetic introgression from certain hatchery-origin fish species and life history types. Self-sustaining natural production of several Hood Canal summer-run chum salmon populations introduced through hatchery-based supportive breeding programs into streams where the race of the species had become extirpated has been restored over the short term (PNPTT and WDFW 2007). However, prospects for retention of the populations over the longer term are unknown. Recent studies have indicated that Chinook salmon originating from hatchery programs can contribute positively to natural productivity for the species (Hess et al. 2012; Anderson et al. 2012; Ford et al. 2012).

In the Dungeness River, the natural-origin Chinook salmon population is at critically low abundance and returning adults may have difficulty finding mates. Under such circumstances, supportive breeding is expected to benefit productivity of the natural population (NMFS 2004c). As the Dungeness River Hatchery program is implemented, because the number of naturally spawning Dungeness stock fish will increase and available habitat is under-seeded, productivity is expected to improve relative to reliance on natural spawning by natural-origin fish only. Adult fish from the supportive breeding program that escape to spawn naturally would thus contribute positively to natural Chinook salmon productivity. However, recent estimates of egg to juvenile outmigrant and recruit per spawner survival rates reflect a general low and declining productivity for the naturally spawning aggregate hatchery-origin and natural-origin population (Figure 4), consistent with the current degraded condition of spawning, rearing, and migration habitat in the watershed. Recovery of properly functioning watershed processes and conditions is required, commensurate with increased spawner abundance provided by the supplementation program, for population productivity to improve.

Beneficial effect (Marine-derived nutrients)

Listed Chinook salmon and steelhead in the Dungeness River watershed would benefit from the deposition of hatchery program-origin salmon carcasses resulting from natural escapement and coho and pink salmon carcass distribution after spawning through the programs. Decaying carcasses of spawned adult hatchery-origin fish will contribute nutrients that increase productivity in the watershed, providing food resources for naturally produced Chinook salmon and steelhead (WDFW 2013a). Diminished numbers of salmonids returning to spawn in the Dungeness River has resulted in nutrient deficiencies compared to historical conditions, affecting salmon and steelhead productivity potential (Haring 1999). Adult salmon and steelhead spawning escapements have significantly declined to a fraction of their historical abundance, raising concerns about a lack of marine-derived nutrients returning back to the system in the form of salmon carcasses (Haring 1999). With natural spawning by hatchery-origin fish, and any hatchery carcass seeding efforts, a substantial amount of decaying fish, and marine derived nutrients would be deposited through implementation of the three hatchery programs (Table 12). The annual number of salmon carcasses would be expected to increase in the watershed, as would marine-derived nutrient benefits, as the progeny of naturally

Table 12. Estimated biomass of marine-derived nutrients (MDN) that would be deposited by naturally spawning adult hatchery-origin salmon returning to the Dungeness River for natural spawning and from carcass distribution from the hatcheries during the preservation and recolonization phases of restoration.

Species	Juvenile Fish Release Level (Goals)	% Survival to Escapement	Total Hatchery-Origin Adult Escapement	Average Individual Adult Fish Weight (lbs)	Potential MDN Biomass (lbs)
Chinook salmon	150,000 subyrlg. 50,000 yrlg.	0.43[1] 0.85[1]	1,033	15.0	15,495
Coho salmon	500,000	0.96[2]	4,800	7.0	30600
Pink salmon	100,000	1.0[3]	1,000	4.0	4,000
TOTAL	-	-	-	-	53,095

[1] Juvenile fish survival rate to escapement estimates for Chinook salmon assume total smolt to adult return (SAR) survival rates of 0.5% for subyearlings and 1.0% for yearlings (approximate realized rates from Fuss and Ashbrook 1995), and escapement rates for surviving fish of 85% (estimated contribution of total coded wire tag recoveries for Gray Wolf Pond subyearling releases (Table 3.3.1.2 in WDFW 2013a), less broodstock needs of 112 fish.

[2] Juvenile fish survival rate to escapement estimates for coho salmon derived assuming realized SAR for Dungeness River Hatchery of 3% and escapement rate of 32% (net harvest plus escapement) (Fuss and Ashbrook 1995).

[3] Juvenile fish survival rate to escapement estimates for pink salmon assumes fry to adult return survival rate of 1.0% (goal survival rate level for hatchery chum salmon fry released at same 1 gram size from Fuss and Ashbrook 1995).

spawning hatchery- and natural-origin fish increase in adult return abundance over time, commensurate with the success of on-going habitat restoration efforts.

2.4.2.3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas

Negligible effect (Fish disease pathogen transfer and amplification)

BMPs addressing fish health, including fish health maintenance and hatchery sanitation procedures applied during broodstock collection, mating, fish incubation, rearing, and release, are detailed in performance standard and indicator, adult management, and fish rearing and release sections of each of the Dungeness River Hatchery salmon HGMPs. Fish health monitoring and evaluation measures are also described in those HGMP sections.

The hatchery programs would be operated in compliance with "Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State" protocols (NWIFC and WDFW 2006). The co-manager policy delineates Fish Health Management Zones and defines inter and intra-zone transfer policies and guidelines for eggs and fish that are designed to limit the spread of fish pathogens between and within watersheds (NWIFC and WDFW 2006). They would also comply with standard fish health diagnosis, maintenance and hatchery sanitation practices referenced in the policy (as per PNFHPC (1989) and American Fisheries Society-Fish Health Section (AFS-FHS) 1994guidelines) to reduce the risks of fish disease pathogen amplification and transfer within the hatchery and to fish in the natural environment. For all salmon propagated through the Dungeness River Hatchery programs, fish health specialists and pathologists from the WDFW Fish Health Section would provide fish health management support and diagnostic fish health services (WDFW 2013a; 2013b; 2013c).

Adult fish collected as broodstock for the program would be held at the hatcheries for up to a five month period before they are spawned. Because the holding period is extended in duration, minimally invasive fish health maintenance procedures would be conducted during the pre-spawn holding period to reduce the risk of handling injuries that would lead to secondary infections (e.g. dermal fungal invasion). Behavior and external condition of the fish would be routinely observed, in addition to occasional non-lethal sampling to detect external parasites in conjunction with other handling. Any fresh pre-spawning mortalities of adult fish would be removed from holding ponds and examined. If necropsy is warranted, the carcass would be either examined immediately by fish health staff or frozen and examined during the next monitoring visit. At the time of annual spawning, lots of 60 adult fish would be sampled and analyzed for pathogens and parasites at the tribal and state fish health labs. Fish health would be monitored by hatchery staffs throughout the juvenile fish rearing periods at the hatcheries. WDFW fish health professional staff would visit the hatchery fish rearing sites monthly, or as needed, to perform routine monitoring of juvenile fish, advise hatchery staff on disease findings, and recommend remedial or preventative disease treatments with administration of therapeutic and prophylactic treatments when appropriate. Vaccinations of rearing fish populations to reduce the incidence of specific fish diseases would also be provided, as needed. Consistent with the co-manager fish health policy (NWIFC and WDFW 2006), all fish scheduled for release from the hatcheries would be certified as disease-free prior to release through collection and diagnostic analysis of representative samples of pre-smolts. WDFW maintains a fish health database to identify trends in fish health and disease and implement fish health management plans based on findings.

BMPs for monitoring the health of fish in hatcheries specified in the co-managers' fish health policy (NWIFC and WDFW 2006) would reduce the likelihood of disease transmission from hatchery salmonids to naturally produced fish. When implemented, these BMPs would help contain any fish disease outbreaks in the hatcheries, minimizing the release of diseased fish from hatcheries, and reducing the risks of disease transfer and amplification to natural-origin fish (NMFS 2012b). BMPs applied to minimize risks of adverse effects on listed Chinook salmon and steelhead associated with fish disease pathogen transfer and amplification for the three proposed Dungeness River Hatchery HGMPs are based on best available science, and are expected to be sufficiently protective of listed natural and hatchery fish populations. Further, high egg to smolt survival rates for fish propagated in the proposed hatchery programs (sections 9.1.1 and 9.2.1 in WDFW 2013a; 2013b; 2013c) indicate that protocols for monitoring and addressing the health of fish in hatcheries have been successful in containing disease outbreaks in the Dungeness River Hatchery programs, minimizing the release of fish carrying disease pathogens, and reducing the risk of transfer to wild fish populations. For these reasons, fish disease pathogen transmittal and amplification risks that would be associated with HGMP implementation appear to be adequately addressed and minimized.

Negative effect (Competition)

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Adverse impacts of competition may result from direct interactions, whereby a hatchery-origin fish interferes with the accessibility to limited resources by naturally produced fish, or through indirect means, as when utilization of a limited resource by hatchery fish reduces the amount available for naturally produced fish (SIWG 1984). Release of non-indigenous hatchery–origin species into a listed species' habitat or where they may access the habitat of listed species may harm listed species and therefore constitutes a "take" under the ESA (NMFS 1999). Specific hazards associated with adverse competitive impacts of hatchery salmonids on listed naturally produced salmonids may include food resource competition, competition for juvenile rearing sites, and, to a lesser extent, competition for spawning sites (NMFS 2012b). For these competition risks between fish origins or fish species to occur, substantial levels of spatial and temporal overlap, and limited resources shared by the fish must exist.

Table 13 compares the relative size and the spatial and temporal distribution of natural-origin juvenile Chinook salmon and steelhead, and hatchery-origin Chinook, coho, and pink salmon juveniles. Considering natural fish occurrence and proposed hatchery-origin fish life stage and release timings into the Dungeness River where competitive interactions would potentially occur, hatchery-origin Chinook and coho salmon would be the fish with substantial spatial and temporal overlap with natural-origin juvenile listed Chinook salmon and steelhead. Hatchery-origin pink salmon released as fry have habitat and diet preferences that differ from Chinook salmon and steelhead (SIWG 1984), so no competition effects are expected for this hatchery species. To reduce the risk of spatial and temporal overlap between juvenile hatchery-origin and listed natural-origin fish that might lead to competition effects, the primary juvenile hatchery-origin fish release locations for the programs would be in the lower Dungeness River.

The release of fish in the lower watershed would reduce the intensity and duration or interactions with natural-origin fish relative to releasing hatchery fish in upper portions of the watershed where natural-origin fish would primarily rear. All coho salmon smolts would be released from Dungeness Hatchery at RM 10.5, as would one-third (50,000) of subyearling Chinook salmon. All yearling Chinook salmon and all pink salmon would be released from Hurd Creek Hatchery, which is tributary to the Dungeness River at RM 2.7. Up to 100,000 subyearling Chinook salmon smolts would be released in mid or upper river areas through the acclimation pond sites at Dungeness River (RM 15.8) and Gray Wolf River (RM 1.0). Fish released from these locations would emigrate seaward through downstream areas where rearing or migrating natural-origin fish may also be present.

In addition to spatial overlap, the degree to which listed natural-origin fish and hatchery-origin juvenile salmon and steelhead will interact, potentially leading to competition effects, also depends on the opportunity for temporal overlap between the two groups (Table 13). All fish produced by the programs for release in the watershed would be released as seawater-ready fish (smolts or fry) as a measure to foster rapid emigration seaward, and clearance from watershed area where they may compete with natural-origin fish. WDFW juvenile out-migrant trapping in the lower Dungeness River in 2006 showed that an estimated 99.7% of the hatchery yearling Chinook salmon released from Dungeness and Hurd Creek hatcheries migrated past the river mouth trapping site within seven days (Topping et al. 2006). Based on this 2006 survey and the nature of outmigrating seawater-ready salmonids, even allowing for year-to-year variation, NMFS estimates that in most years at least 90% of smolts would be out of the

Table 13. Comparative individual sizes and freshwater occurrence timings for rearing and/or emigrating natural-origin salmon and steelhead juveniles by species and life stage, and hatchery-origin salmon juveniles proposed for release from the Dungeness River Hatchery programs.

Species/Origin	***Life Stage***	***Individual Size (mm fork length avg. and range)***	***Occurrence or Release Timing***
Chinook salmon (wild)	Fry	*39 (33-79)*	*Mid-February-April*
Chinook salmon (wild)	Parr-Subyrlg.	*78 (43-120)*	*May-July*
Chinook salmon (wild)	Yearling	*120 (92-154)*	*late March-May*
Chinook salmon (hatchery)	Sub-yearling	*103 (57-103)*	*May-June*
Chinook salmon (hatchery)	Yearling	*181 (155-196)*	*April*
Steelhead (wild)	Fry	*60 (23-100)*	*June-Oct.*
Steelhead (wild)	Parr	*96 (65-131)*	*Oct.- mid May*
Steelhead (wild)	Smolt	*165 (109-215)*	*late April-June*
Coho (wild)	Fry	*30 (29-36)*	*March*
Coho (wild)	Parr	*56 (37-74)*	*April-April*
Coho (wild)	Yearling	*107 (74-190)*	*Late April-May*
Coho (hatchery)	Yearling	*140 (131-156)*	*May-June*
Coho (hatchery)	Fry	*65 (55-72)*	*May-June (Cooper Ck)*
Chum (wild)	Fry	*38 (33-50)*	*February-May*
Pink (wild)	Fry	*34 (32-43)*	*March-April*
Pink (hatchery)	Fed fry	*50 (40-52)*	*April*

Wild Chinook salmon data from Topping et al. 2006; Topping and Kishimoto 2008 (fry and parr data for the Dungeness River), Beamer et al. 2005 (yearling data), and WDFW juvenile out-migrant trapping reports (general fish size range and timing data from Seiler et al. 2000; 2003; 2004; Volkhardt et al. 2006a; Volkhardt et al. 2006b; Kinsel et al. 2008).
Wild steelhead individual size data and occurrence estimates from Shapovalov and Taft (1954) and WDFW juvenile out-migrant trapping reports (Kinsel et al. 2008; Volkhardt et al. 2006a; Volkhardt et al. 2006b).
Wild coho data for Green River from Topping et al. 2008 (smolts); Beacham and Murray (1990) and Sandercock (1991) (fry); parr size range extrapolated from smolt and fry data considering year-round residence.
Wild chum data from Volkhardt et al. 2006a (Green River fall-run), and Tynan (1997) (Hood Canal summer-run).
Wild pink salmon data from Topping and Kishimoto 2008 (Dungeness River pink salmon).
Hatchery-origin fish release size and timing data are average individual fish size and standard release timing targets proposed in the Dungeness River Hatchery salmon HGMPs, and average size and size range data for regional hatcheries from WDFW and PNPTT 2000 (estimated mm fish lengths converted from fish per pound data using conversion tables in Piper et al. (1986)).

system in hours/days, and it would be reasonable to expect that the number of smolts remaining in the river within 10 days would be close to zero.

The majority of juvenile Chinook salmon produced through the Dungeness River Hatchery program would be released from the rearing sites as sub-yearling smolts in late May through early June, after the majority of natural-origin juvenile Chinook salmon and steelhead have emigrated seaward. Release of subyearling Chinook salmon in late spring is designed to reduce temporal overlap with juvenile listed fish, and the opportunity for substantial competition effects from the hatchery-origin subyearling Chinook salmon release component of total production of the species. Yearling Chinook salmon would be released from Hurd Creek Hatchery in April, and there would be the potential for temporal overlap with any emigrating natural-origin Chinook salmon and steelhead juveniles present in the two miles of lower river, downstream of the hatchery and in the estuary. Hatchery yearling coho salmon would be released as rapidly migrating smolts from Dungeness River Hatchery that (as shown for Chinook salmon yearlings) would quickly leave downstream areas where potential interactions with natural-origin fish would may occur. Coho salmon smolt releases would be delayed until May through June each year as a measure to further minimize interactions with, and competition risks to, the majority of rearing and emigrating natural-origin Chinook salmon and steelhead present in the lower watershed each year. Coho salmon fry would be transported for release into Cooper Creek, a Strait of Juan de Fuca tributary where no listed fish species are present that would be affected through competition. Fall pink salmon fry would be released from Hurd Creek Hatchery during the natural-origin pink salmon fry emigration period in April. Because of their release timing, fall pink salmon fry would have the potential to interact with, and compete with, any co-occurring natural-origin Chinook salmon and steelhead juveniles in the 2.7 miles of the lower river downstream of the hatchery and in the estuary.

The co-managers have included hatchery management measures in the proposed HGMPs designed to reduce competition risks to listed fish from hatchery-origin salmon in the Dungeness River action area:

- As a primary juvenile hatchery fish production strategy, all yearling coho salmon and Chinook salmon, all pink salmon fry, and one-third of the total number of subyearling Chinook salmon produced each year would be released into the lowest portion of the watershed from Dungeness River Hatchery (RM 10.5) or Hurd Creek Hatchery (RM 2.7). The lower river release locations limit the duration of hatchery fish presence in freshwater, reducing the duration of interaction with any natural-origin fish rearing or migrating adjacent to or downstream of the hatcheries.

- All sub-yearling Chinook salmon, yearling Chinook salmon, pink salmon fry, and yearling coho salmon would be released from the hatcheries into the Dungeness River as readily migrating fish, in a physiological condition ready for transition to a seawater existence. The practice of releasing only actively migrating smolts that would exit freshwater rapidly would reduce the duration of interaction with natural-origin Chinook salmon or steelhead in the lower river of a life stage vulnerable to competition for food or space.

- Hatchery- and natural-origin emigration timing and abundance would be monitored each year through operation of the WDFW juvenile outmigrant trapping program in the lower Dungeness River at RM to evaluate whether hatchery juvenile release timings pose a risk of substantial harmful ecological interactions with listed natural-origin fish.

Alternate hatchery fish release timings or other mitigation measures would be developed to minimize such interactions.

Negative effect (Predation)

Risks to naturally produced salmon and steelhead attributable to direct predation (direct consumption) or indirect predation (increases in predation by other predator species due to enhanced attraction) can result from hatchery salmonid releases (NMFS 2012b). Hatchery-origin fish may prey upon juvenile naturally produced salmonids at several stages of their life history. Newly released hatchery smolts have the potential to consume naturally produced fry and fingerlings that are encountered in freshwater during downstream migration. Hatchery smolts that do not emigrate and instead take up stream residence near the point of release (residuals) have the potential to prey on rearing natural-origin juvenile fish over a more prolonged period. Hatchery salmonids planted as non-migrant fry or fingerlings, also have the potential to prey upon natural-origin salmonids in the freshwater where they co-occur. In general, naturally produced salmonid populations will be most vulnerable to predation when naturally produced populations are depressed and predator abundance is high, in small streams, where migration distances are long, and when environmental conditions favor high visibility (NMFS 2012b).

The risk of hatchery-origin smolt predation on natural-origin juvenile fish is dependent upon three factors: (1) the hatchery fish and their potential natural-origin prey must overlap temporally; (2) the hatchery fish and their prey must overlap spatially; and, (3) the prey should be less than 1/3 the length of the predatory fish (NMFS 2012b).
Table 13 compares the relative size and the spatial and temporal distribution of natural-origin juvenile Chinook salmon and steelhead, and hatchery-origin Chinook, coho, and pink salmon juveniles. Considering natural fish occurrence and proposed hatchery-origin fish life stage and release timings into the Dungeness River where predator-prey interactions would potentially occur, the hatchery-origin species and life stages with substantial spatial and temporal overlap with vulnerable juvenile listed Chinook salmon and steelhead would be yearling Chinook and coho salmon released from Dungeness River Hatchery and Hurd Creek Hatchery. Chinook salmon yearlings released in April into Hurd Creek through the proposed Dungeness River Hatchery program would be of large enough size to prey on juvenile Chinook salmon less than approximately 50 mm fork length present in the lower Dungeness River when the hatchery fish would be released. Hatchery yearling Chinook salmon would not encounter juvenile natural-origin steelhead in April that would be of a size vulnerable to predation. Although of similarly large size at the time of their release, hatchery-origin coho salmon yearlings would be released in mid-May, when any co-occurring natural-origin Chinook salmon and steelhead would generally be too large to be vulnerable to predation.

The proposed programs for yearling Chinook and coho salmon would reduce the potential for predation on listed juvenile salmon and steelhead through application of the following measures:

- All hatchery-origin Chinook salmon yearlings would be released as migration-ready smolts directly from Hurd Creek Hatchery, which is located in the lowest portion of the river (RM 2.7).

- All hatchery-origin coho salmon yearlings would be released as migration-ready smolts into the Dungeness River from Dungeness River Hatchery at RM 10.5. These release sites minimize the areal extent where any co-occurring natural-origin fish would be exposed to interactions with the yearling hatchery fish.
- All hatchery fish released as migration-ready smolts have been shown through juvenile outmigrant trapping studies to quickly emigrate from the lower Dungeness River where they would disperse into marine waters, minimizing the duration of interaction with any natural-origin salmonids of a size vulnerable to predation.
- There will be few natural-origin fish of any species in the lower Dungeness River that would serve as prey for hatchery-origin yearlings when and where proposed juvenile fish releases would occur due to the currently depressed status of listed fish populations in the watershed.
- If naturally-produced smolt outmigration timing, determined by monitoring in the mainstem or tributaries, suggests that proposed release timings for Chinook salmon and coho salmon from the hatcheries would result in predation on listed natural-origin fish, alternate release timings or other mitigation measures would be developed to minimize such interactions.

2.4.2.4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean

Negligible effect

Researchers have also looked for evidence that marine area carrying capacity can limit salmonid survival (Beamish et al. 1997; HSRG 2004). Some evidence suggests density-dependence in the abundance of returning adult salmonids (Bradford 1995; Emlen et al. 1990; Lichatowich et al. 1993), associated with cyclic ocean productivity (Beamish and Bouillon 1993; Beamish et al. 1997; Nickelson et al. 1986). Collectively, these studies indicate that competition for limited food resources in the marine environment may affect survival (also see Brodeur et al. 2003). Large scale hatchery production may exacerbate density dependent effects when ocean productivity is low. Puget Sound region-origin salmon survival may be intermittently limited by competition with odd-year pink salmon (Ruggerone and Goetz 2004), particularly when ocean productivity is low (Beamish and Bouillon 1993; Beamish et al. 1997; Mahnken et al. 1998; Nickelson et al. 1986).

Regarding predation risks posed by hatchery-origin salmonids in estuary and marine areas, NMFS (2002) concluded that predation by hatchery fish on natural-origin smolts or rearing ocean-phase fish is less likely to occur than predation on younger life stages when natural-origin fish are in freshwater. Chinook salmon, after entering the marine environment, generally prey upon fish one-half their length or less and consume, on average, fish prey that is less than one-fifth of their length (Brodeur 1991). During early marine life, predation on natural-origin Chinook salmon will likely be highest in situations where large, yearling-sized hatchery fish encounter fry (SIWG, 1984). Studies by Seiler et al. (2004) have shown that natural-origin Chinook salmon entering the marine environment at that time are too large for predation. Likely reasons for apparent low predation rates on Chinook juveniles by larger Chinook are: 1) due to rapid growth, natural-origin chinook are better able to elude predators and are accessible to a smaller proportion of predators due to size alone; 2) because Chinook salmon have dispersed, they are present in low densities relative to other fish and 3) there has either been learning or selection for some predator avoidance (Cardwell and Fresh 1979). In a literature review of Chinook salmon food habits and feeding ecology in Pacific Northwest marine waters, Buckley (1999) concluded that cannibalism and intra-generic predation by Chinook salmon are rare events.

In general, it is difficult to make judgments regarding the carrying capacity of the Salish Sea, and whether ecological effects associated with hatchery-origin salmon production are adversely affecting natural-origin fish productivity and survival at currently depressed natural-origin abundance levels for some species and populations. The limited information available is insufficient to determine definitive impacts. In addition, assigning marine area ecological and demographic effects specifically for hatchery-origin salmon production from the Puget Sound region would be speculative, because hatchery-origin fish intermingle at the point of ocean entry with natural-origin fish and hatchery-origin anadromous salmonids migrate to the Puget Sound from many other Pacific Northwest regions. At best, it can be said that, during years of limited food supply, juvenile fish survival and size may be reduced. Hatchery enhancement of Chinook salmon populations could exacerbate density-dependent effects during years of low ocean productivity. However, there are no studies that demonstrate an association between the magnitude of hatchery salmon smolt release numbers in the Salish Sea and adverse changes in natural-origin Chinook salmon survival rates in the estuary or the ocean. It is possible that an increase in hatchery release numbers might decrease ocean survival rates for natural-origin salmon, and a decrease in release numbers might improve ocean survival rates for natural-origin salmon.

Available knowledge and research abilities are insufficient to discern the role and contribution of hatchery fish in any density-dependent interactions affecting salmon and steelhead growth and survival in the Salish Sea and in the Pacific Ocean. From the scientific literature, the conclusion seems to be that the influence of density-dependent interactions on growth and survival is likely small compared with the effects of large scale and regional environmental conditions (Beamish et al. 1997; Beamish et al. 2003; Beamish et al. 1995). While there is evidence that hatchery production on a scale many times larger than the production considered in this biological opinion can impact salmon survival, the degree of impact or level of influence is not yet understood or predictable. NMFS will monitor emerging science and information and will reinitiate section 7 consultation in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation.

The proposed Dungeness River Hatchery salmon programs would lead to unsubstantial changes in the total number of anadromous salmonids encountered by listed species in Puget Sound and Pacific Coastal marine waters outside of the Dungeness River. For example, the total numbers of juvenile Chinook salmon that would be released through the Dungeness River Hatchery program are 150,000 subyearlings and 50,000 yearlings. This annual production would be 0.4% of the 46.1 million hatchery-origin Chinook salmon released into Puget Sound watersheds each year. Further, the number of juvenile hatchery fish that survive to reach the ocean would be substantially less than the number produced and released from the hatchery ponds. Exposure to natural conditions, including predation by piscivorous fish, bird, and mammal species, leads to high levels of mortality to juvenile hatchery-origin fish immediately upon their release into the natural environment. Topping and Kishimoto (2008) and Topping et al. (2008) estimated that 38% and 65% of the subyearling Chinook salmon released from the Gray Wolf Acclimation Pond in 2006 and 2007 survived the approximately 16 mile migration downstream in the mainstem Dungeness River to near the river mouth. As a surrogate for expected survival rates in the river migration corridor for Hurd Creek Hatchery pink salmon fry released into the Dungeness River at RM 2.7, freshwater survival for chum salmon fry released into a Hood Canal stream at a 1 gram size was estimated to be 73.7% for fish released into a Puget Sound stream approximately 1.5 miles upstream from saltwater entry (Fresh et al. 1980). Juvenile out-migrant trapping studies directed at post release survival for Green River hatchery fish estimated that 10.6% of Chinook salmon yearlings, and 13% to 70% of yearling steelhead released from upstream hatcheries each year survived to reach a trapping operation at RM 33 (Seiler et al. 2004). Considering that Dungeness River Hatchery-origin salmon would commingle with many other hatchery and wild juvenile salmonid populations besides those from Puget Sound in marine waters (e.g., Fraser River, Columbia River, Washington Coast), the relatively unsubstantial number of hatchery fish released through the proposed programs and surviving to reach seawater would have inconsequential effects on listed species.

Although important at the Dungeness River watershed scale, the number of adult fish produced by the proposed hatchery actions would also represent an unsubstantial proportion of the total abundance of each species present in Puget Sound and in Pacific Coastal marine areas. As shown in Table 14, the average total annual return to Puget Sound of Dungeness Chinook salmon (hatchery and natural-origin) over the past 12 years was unsubstantial, and only 0.27% of the total run size of the species for the entire total annual abundance of the species in the Puget Sound region. For comparison to the total Dungeness River and Puget Sound average Chinook salmon adult returns, the estimated Chinook salmon from all regions in Washington State and British Columbia in Pacific Ocean coastal waters averages approximately 1,000,000 fish (L. LaVoy, NMFS, pers. comm., January 6, 2012). The total return of wild pink salmon to the Dungeness River (summer and fall-run adult fish) was 0.07% of the total return for the species for the year 1999-2011. The proposed WDFW pink salmon hatchery program in the Dungeness River may contribute 1,000 fish to the average total return of the species to the river of 27,746 fish. Coho salmon produced largely by the Dungeness River coho salmon program (WDFW 2013c) contribute an annual average of 1.65% to the total average Puget Sound return of the species.

For the above reasons, NMFS does not believe it is possible to meaningfully measure, detect, or evaluate the specific effects of Dungeness River Hatchery-origin juvenile and adult salmonid production on listed species in Puget Sound and the Pacific Ocean, due to the low magnitude of, and low likelihood for, effects in those locations.

2.4.2.5. Research, monitoring, and evaluation

Negligible effect

The proposed hatchery program actions address the five factors that NMFS takes into account to analyze and weigh the beneficial and negative effects of hatchery RM&E (see section 2.4.1.5). The programs include RM&E to monitor compliance with this opinion and to inform

Table 14. Estimated average total adult returns of Dungeness River Chinook, pink, and coho salmon to Puget Sound compared with the total returns of the species.

Species	Average Puget Sound Adult Return—Dungeness River-Origin	Average Puget Sound Return for the Salmon Species	Dungeness-Origin Salmon Percent of Total Species Return
Chinook salmon	693[1]	231,038 [1/]	0.27
Pink salmon	26,648[2]	3,925,558 [2/]	0.07
Coho salmon	13,806[3]	837,405 [3/]	1.65

[1] Estimated total terminal area adult return of Dungeness Chinook and for all Chinook salmon in Puget Sound for 2000-2011 from WDFW run reconstruction, January 23, 2013.
[2] Dungeness River and total Puget Sound wild odd year pink salmon run reconstruction data for terminal area adult returns for 1999-2011 from A. Dufault, WDFW, pers. comm., September 6, 2013.
[3] Dungeness River and Puget Sound coho salmon terminal area run size data for 2000-2011 from WDFW run reconstruction, J. Haymes, WDFW, pers. comm., January 7, 2013.

future decisions regarding how the hatchery program can make adjustments that further reduce risks to ESA-listed Dungeness River Chinook salmon and steelhead. Negligible lethal and sub-lethal effects on listed species are expected to occur as a result of implementing RM&E actions.

In general, monitoring and evaluation actions associated with implementation of the proposed programs would include measures designed to assess supportive breeding program performance and effects. Spawning ground surveys would be used to estimate annual escapement and distribution of each species by origin (hatchery and natural) in natural spawning areas within the watershed. Biological sampling of carcasses would be conducted to determine age class, sex ratios, and fish origin through mark and/or tag (e.g., CWT) recoveries[15]. All salmon reared in the three hatchery programs would be monitored and sampled for mortality rates by life stage, fish health (by fish health professionals), and for population census purposes. All hatchery-origin fish would be marked and/or tagged prior to their release into the natural environment to allow for assessment of smolt to adult survival rates and to determine origin of adult returns.

The primary monitoring and evaluation objective for the two conservation hatchery plans for Chinook salmon and pink salmon (WDFW 2013a; 2013b) is assessment of the status of the target Dungeness River populations and the success of the programs in achieving restoration goals for the species. Monitoring and evaluation actions that would be implemented to determine whether this objective is met include spawning ground/redd surveys and hatchery escapement monitoring to determine total Chinook and pink salmon adult returns to the Dungeness River and the hatcheries. The number and distribution of tagged, untagged, and otolith-marked fish escaping to the watershed each year would be monitored to determine the status of the natural- and hatchery-origin salmon returns relative to goal levels. In addition to regular foot surveys to census salmon spawning abundance, count redds, and sample carcasses

[15] Any listed fish takes resulting from carcass sampling are previously authorized through a separate NMFS biological opinion addressing WDFW research, monitoring, and evaluation programs (NMFS 2015a).

to identify fish origin in natural spawning areas, adult fish abundance, origin, and distribution data would be collected through monitoring of weir counts at Dungeness River Hatchery and (when operating) at the Dungeness River (Game Farm) mainstem weir. Adult fish returns, timing, age class, sex ratio, and fish health condition data would be collected at the hatchery and weir locations to monitor the effects of the programs in increasing adult returns and maintaining the run traits of the target populations. Juvenile fish outmigrant data collected through annual operation of a downstream-migrant trap in the mainstem Dungeness River would allow for assessment of the natural spawning success of the salmon populations. Operated by WDFW's Wild Salmon Production Evaluation Unit, and permitted for listed fish takes through a separate ESA review process, juvenile outmigrant trapping would provide data regarding abundance by species and origin, and salmon migrational behavior (seasonal timing, migration rate, and migration duration). These data would be essential for identifying Chinook and pink salmon survival and productivity, and the effects of the conservation hatchery programs in assisting in the restoration of viable populations.

The demographic and ecological effects of the three salmon programs on listed salmon and steelhead populations in the Dungeness River are also monitored. The primary objective would be to determine whether the programs were harming juvenile and adult Chinook salmon, summer chum salmon, or steelhead as a result of hatchery operations, broodstock collection, and production of juvenile fish. In general, actions taken at the hatcheries to meet this objective would include monitoring of water withdrawal and effluent discharge to ensure compliance with permitted levels; monitoring of broodstock collection, egg take, fish survival rates, and smolt release levels for each program to determine compliance with program goals; and fish health monitoring and reporting in compliance with co-manager Fish Health Policy (NWIFC and WDFW 2006) requirements. Data collected through operation of the WDFW juvenile out-migrant trap in the lower river, and a juvenile coho salmon outmigrant trap in Matriotti Creek operated by the Jamestown S'Klallam Tribe[16], would allow assessment of emigrating natural- and hatchery-origin fish abundance and overlap in timing between natural-origin species and newly released hatchery-origin fish. Other data collected through the two trapping programs that would be used to assess hatchery effects are fish size, origin (marked/tagged vs. unmarked/untagged) and other biological data (e.g., tissue samples for genetic analyses). To ensure proper care and maintenance of trapped fish as a means to minimize take of listed fish, the trap would be checked by WDFW frequently to reduce holding duration, and trapping would be suspended during high flow events to reduce the risk of fish injury and mortality (WDFW 2013a). Other risk aversion measures that are currently implemented to minimize take are specified in annual NMFS 4(d) Evaluation and Determination documents authorizing tribal research in Puget Sound (NMFS 2009).

Masking of natural-origin Chinook salmon population status is not a risk factor. All fish produced by the Dungeness River Hatchery Chinook salmon program would be marked with a CWT to allow for their differentiation from natural-origin fish upon their return as adults to the river. No adipose fin-clips would be applied to juvenile Chinook salmon prior to release because the program would be implemented to increase the number of adult fish escaping to

[16] These juvenile salmon outmigrant trapping programs are not part of the proposed action considered in this opinion, as both were previously evaluated and approved through separate ESA consultations (NMFS 2009; NMFS 2015a).

the hatchery release site and into natural spawning areas, and not to provide harvest opportunity for mark selective fisheries (WDFW 2013a). All juvenile fish produced by the Dungeness River Hatchery pink salmon and coho salmon programs would be marked with an adipose fin clip for program performance monitoring purposes, and to assist in gauging effects of the programs on listed Chinook salmon and steelhead in natural spawning and rearing areas.

2.4.2.6. Operation, maintenance, and construction of hatchery facilities

The majority of the water supply systems used for salmon rearing in the proposed programs are designed and operated such that groundwater extraction and surface water withdrawals are not expected to reduce survival, spatial distribution, and productivity of natural-origin Dungeness River Chinook salmon and steelhead. However, the hatchery water intake structures on the Dungeness River and Canyon Creek supplying Dungeness River Hatchery, and on Hurd Creek for the Hurd Creek Hatchery, do not meet current federal water intake screening or fish passage criteria (WDFW 2013a).

The Canyon Creek water intake is adjacent to a small dam that completely blocks anadromous fish access to upstream spawning habitat. As described in section 2.3.2, above, WDFW is in the process of providing fish passage on Canyon Creek consistent with a NMFS approval for construction of a fish ladder (NMFS 2013b). The NMFS approval for the ladder construction will bring the structure into compliance with NMFS (2011b) fish passage criteria. The intent during ladder construction and normal operation of the fish ladder is to ensure that a minimum creek flow of 22 cubic feet per second (cfs) will enter the fishway. Hatchery operation will never cause the withdrawal of 100 percent of the flow, as use of the water by the hatchery would only occur during the winter months—when flows are highest—and floods or icing of the main intakes on the Dungeness River prevent their use. Flow maintained at least at this level will maintain sufficient in-stream flow in the fish ladder and in the reach downstream of the dam to allow fish passage (NMFS 2013b).

WDFW is also bringing water intake structures that supply water for Dungeness River Hatchery into compliance with current NMFS fish passage criteria. Work on the structures is planned for completion by fall 2019. The current three structures used to withdraw water from the mainstem Dungeness River will be reduced to one structure, which will remain passable to upstream and downstream migrating fish (WDFW 2013a). Until that construction is complete, the Dungeness Hatchery structure is expected to pose unsubstantial fish passage risks to migrating juvenile and adult salmon. Although out of compliance with current NMFS (2011b) fish passage criteria (the reason the structures are identified as a risk factor in this review document), no fish passage problems or fish mortality events have been observed during operation of the water intakes. Screening on the current water intakes on the Dungeness River mainstem does not meet current NMFS screening requirements (NMFS 2011b), but does meet NMFS previous screening criteria (NMFS 2008a), and NMFS (2011b) states that such screening is adequately protective of listed Chinook salmon and steelhead from impingement and entrainment effects until the structures are renovated, at which time they must meet current NMFS screening criteria (NMFS 2011b). WDFW will ensure that screening on the new water intake is in compliance with the latest NMFS criteria when construction is completed.

As noted in Section 1.3.1.6, Dungeness River Hatchery uses surface water exclusively, currently withdrawn through the water intakes on the mainstem Dungeness River, in addition to the water intake on Canyon Creek. Dungeness River Hatchery may withdraw up to 40 cfs of surface water from the Dungeness River and up to 8.5 cfs from Canyon Creek (Table 15). Assuming hatchery water withdrawals at maximum permitted levels, up to 62 percent of the water during the lowest streamflow on record (65 cfs) or 50 percent of the 99 percent exceedance low flow (80 cfs) in the Dungeness River could be temporarily diverted into Dungeness River Hatchery to support the three salmon hatchery programs, and 13 percent of the water in the river could be withdrawn during median flows (299 cfs) (WDFW 2013a; WDFW 2013b; WDFW 2013c). Up to 100 percent of the water in Canyon Creek could potentially be temporarily diverted into Dungeness River Hatchery for discharge into the Dungeness River at the hatchery outfall. As noted above, minimum flow criteria were developed in connection with a NMFS consultation on the construction of the Canyon Creek fish ladder and water intake, in order to reduce the risk of migration impedance in Canyon Creek that might result from water withdrawal (NMFS 2013b).

While water intake screens at Hurd Creek Hatchery currently do not comply with NMFS criteria (NMFS 2011b), a recent specific on-site evaluation of the Hurd Creek Hatchery surface water intake screen indicates adverse effects on any migrating salmonids are unlikely (Carlson and Williams 2015). The intake is a horizontal inclined screen that is positioned at the bottom of a pond created in a Hurd Creek side-channel that is away from creek areas where downstream-migrating salmon and steelhead would be present. Rather than operating the intake by directing water flow over (and through) the screen, water is instead backwatered over the screen by the placement of stop logs at the downstream end of the screen. WDFW indicates that because the intake is positioned and operated in an off-channel pond, it is unlikely that the intake screen would contact or cause impingement by natural-origin salmon or steelhead. The Hurd Creek Hatchery facility uses a combination of groundwater withdrawn from five wells, and surface water withdrawn from Hurd Creek for fish rearing and as an emergency back-up source. Under its State water right permit, Hurd Creek Hatchery may withdraw up to 1.4 cfs from Hurd Creek. Under worst case circumstances (in the unlikely event that this amount were withdrawn during the September low flow period for the creek (see below)), up to 70 percent of the water in the Hurd Creek could be withdrawn for fish rearing for the Chinook and fall-run pink salmon programs. Although unlikely to occur because use of surface water at the full permitted amount is not necessary for fish rearing during the annual low flow period, withdrawal of this proportion of the total flow in the creek could potentially affect the ability of adult fish to migrate upstream. WDFW plans to upgrade fish screens at Hurd Creek Hatchery to ensure compliance with NMFS fish passage criteria by summer 2017.

The Gray Wolf Acclimation Pond would be supplied with surface water that is gravity fed from the Gray Wolf River. The Upper Dungeness Acclimation Ponds would be supplied with pumped surface water from the Dungeness River. Up to 1.0 cfs may be withdrawn from the Gray Wolf River for operation of the Gray Wolf Acclimation Pond program, which is no more than 0.5 percent of the flow in the Gray Wolf River at that point. The Upper Dungeness River Acclimation Pond program could potentially use up to 1.0 cfs, which is no more than 0.3 percent of the surface water in the Dungeness River at the point of water withdrawal. The four

Table 15. Water source and use by Dungeness River salmon hatchery facilities.

Hatchery Facility	Surface Water Use Max (cfs) [1]	Surface Water Source	Ground-water Use Min/Max (cfs)	Annual Surface Water Flow (min/mean/max) (cfs) [2]	Maximum Percentage of Total Surface Water Withdrawn for Hatchery Program (%) [4]	Effluent Discharge Location	NPDES Permit Number
Dungeness River Hatchery	40 8.5	Dungeness R. Canyon Creek	0 0	55.5 / 397 / 3,310 2 / 8 / 25	72 / 10 / 1.2 100 / 100 / 34	Dungeness River RM 10.5	WAG 13-1037
Hurd Creek Hatchery	1.4	Hurd Creek	0.9 – 4.5	2 / 5/ 7	70	Hurd Creek RM 0.5	NA [3]
Gray Wolf Acclimation Pond	1.0	Gray Wolf R.	0	/ 189 /	0.5	Gray Wolf River RM 1.0	NA [3]
Upper Dungeness Acclimation Ponds	1.0	Dungeness R.	0	/ 358 /	0.3	Dungeness River RM 15.8	NA [3]

[1] Maximum allowable surface water withdrawal for hatchery use under Washington State water withdrawal permits #S2-06221 and #S2-21709 for Dungeness River and #S2-00568 for Canyon Creek. Hurd Creek Hatchery retains groundwater permit # G2-24026 (WDOE 2012b).

[2] October through September 5-year (2006-2011) mean, minimum, and maximum flow data for the lower Dungeness River from WDOE (2012a) Dungeness River Stream Flow Monitoring Station 18A050, accessible at: https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?wria=18#block2 Flow data collection reach is downstream of five irrigation withdrawal points on the river. Additional source of flow data is EDPU (2005) available at: http://www.clallam.net/environment/elwhadungenesswria.html. Flows presented for the Gray Wolf River and upper Dungeness River are the estimated incremental average annual flows from EDPU (2005). The Dungeness River Management Team recommended minimum instream flows for the lower Dungeness River at seasonal flow levels recommended by the Dungeness Instream Flow Group (Wampler and Hiss 1991; Hiss 1993): November through March: 575 cfs; April through July: 475 cfs; and August through October: 180 cfs. These minimum flows are not based on seasonal, historical Dungeness River flows, but represent flows required to maintain optimal potential fish habitat area (EDPU 2005).

[3] A NPDES Permit is not required for hatchery facilities producing less than 20,000 pounds of fish each year.

[4] Maximum percentage withdrawals derived assuming hatchery use of available surface water up to water maximum permitted surface water withdrawal levels. Actual surface water percentages withdrawn for use in the hatcheries as applied to minimum and mean surface water flows are much lower.

hatchery facilities have current surface water right permits issued by WDOE authorizing water withdrawals up to the amounts identified as maximums in the permits.

The maximum percentage water withdrawal levels described above assume hatchery use of available surface water up to allowable maximums under Washington State surface water withdrawal permits issued for the programs. Actual surface water withdrawal percentages as applied to minimum and mean surface water flows are much lower. Fish biomass in the hatcheries, and required water withdrawal amounts, would reach maximum permitted levels only in the late winter and spring months just prior to fish release dates, when flows in river and tributary sources reach annual maximums (Figure 11).

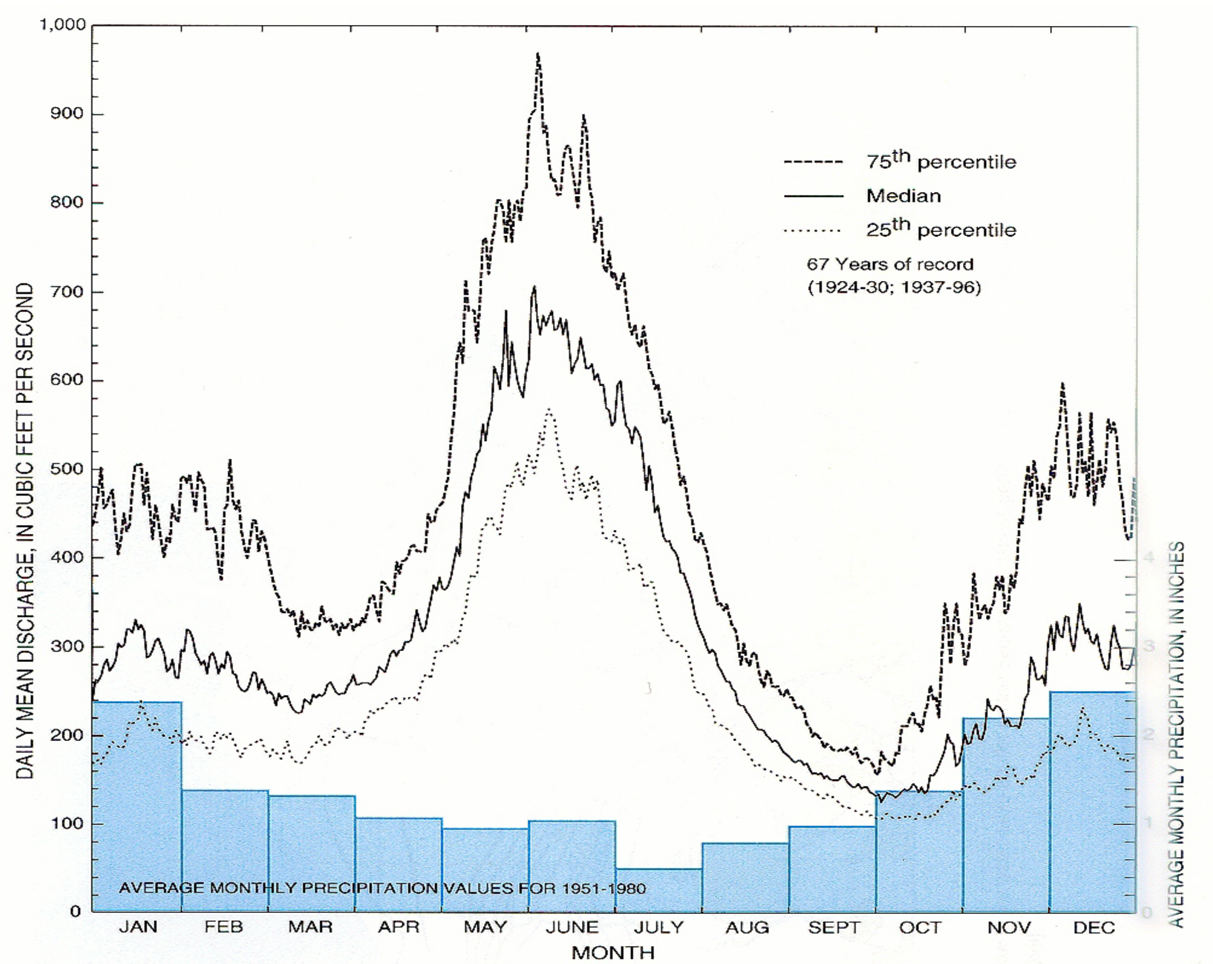

Figure 11. Mean daily discharge for the Dungeness River and average monthly precipitation near Sequim, Washington (Simonds and Sinclair 2002 in Elwha-Dungeness Planning Unit 2005).

Fish biomass and water requirements for fish rearing at the hatcheries are lowest in the late summer and fall months, when annual minimum flows in surface water sources occur. For these reasons, withdrawal of surface and groundwater for use in the hatchery programs would not lead to substantial effects on listed fish. All water used by the hatcheries would be returned to the watercourses near the points of withdrawal. No stream reaches would be dewatered to the extent that natural-origin fish migration and rearing would be impaired, and there would be no net loss in river or tributary flow volumes. We do not expect water withdrawal for use at the hatcheries to result in take of listed salmonids through dewatering of any stream reaches.

Fish rearing at Dungeness River Hatchery is implemented consistent with National Pollutant Discharge Elimination System (NPDES) permit number WAG 13-1037 issued by Washington Department of Ecology (WDOE). Under its NPDES permit, Dungeness River Hatchery operates an off-line settling pond and artificial wetland to remove effluent before the water is released back into the Dungeness River (WDFW 2013a). Although under the 20,000 pounds per year fish production criteria set by WDOE as the limit for concern regarding hatchery effluent discharge effects, at Hurd Creek Hatchery, WDFW has constructed a two-bay pollution abatement pond to treat water prior to its release into Hurd Creek. The fish rearing ponds on the Gray Wolf River and the Upper Dungeness River also have low annual fish production levels, below those for which a NPDES permit is required. The effects of hatchery effluent discharge on downstream aquatic life, including listed Chinook salmon and steelhead, have been adequately minimized through compliance with federal and state permit requirements.

Structures and measures proposed for adult salmon broodstock collection would not substantially affect migration or spatial distribution of natural-origin juvenile and adult Chinook salmon and steelhead. Chinook and coho salmon broodstock would be collected predominantly as volunteers to Dungeness River Hatchery. The facility is off-channel, removed from listed Chinook salmon and steelhead migration and rearing areas, and there would be no effects resulting from operation of broodstock collection actions at the hatchery. Listed Chinook salmon adults would be affected by mainstem Dungeness River (Game Farm) weir at RM 2.5 (when operating), and (only if needed) through netting, gaffing, noodling, or snagging implemented to collect broodstock in the lower river. These actions are proposed as part of the supportive breeding program for the species to augment broodstock collection at the hatchery off-channel trap. Any effects on Chinook salmon or the species' habitat would be minimized through implementation of best management practices. For the Game Farm weir, these practices include use of a removable weir structure that rests on the river bottom and banks with minimal disruption of riverine habitat; placement and operation of the removable weir for three months each year, only when Chinook salmon are migrating; constant surveillance of the weir and trap to ensure proper operation and to safeguard fish trapped; twice daily sorting of fish from the trap to minimize trap holding times, and implementation of fish capture and handling methods that protect the health of fish retained as broodstock or released back into the river. Any netting, gaffing, noodling, or snagging implemented as back-up methods to collect broodstock would be limited to three days per week, and conducted to protect redds and actively spawning fish from disruption, and reduce the risk of incidental harm to Chinook salmon and non-target species. All Chinook salmon adults collected from the river and retained as broodstock would be transferred to Hurd Creek Hatchery, and held in high quality well water, which enhances their survival to spawning. The majority of Dungeness River steelhead migrate into the river in winter, after salmon broodstock collection activities have ended for the season; therefore, any impacts on the listed steelhead would be unsubstantial.

2.4.2.7. Fisheries

NA: Fisheries are not part of the proposed actions. As described in Section 2.3.1, Environmental Baseline, all fisheries affecting ESA-listed species, including fisheries inside and outside of the action area affecting Dungeness River-origin summer chum salmon, Chinook salmon, and steelhead, are subject to consultation on an annual or multi-year basis, depending on the duration of the Puget Sound fishery management plan submitted by the co-managers (NMFS 2015a) (PSTT and WDFW 2015). The effects of fisheries on ESA-listed species to date are described in the Environmental Baseline. There are no changes to those baseline effects as a result of the proposed action, and effects are expected to continue at similar levels to those described in the Environmental Baseline.

2.4.2.8. Effects of the Action on Critical Habitat

Negligible effect

The effects of the proposed hatchery actions on Chinook salmon and steelhead critical habitat, were considered through this consultation, and NMFS found that operation of the hatchery programs will have a negligible effect on shared PCEs for these listed salmonid species in the action area.

Existing hatchery facilities have not led to: altered channel morphology and stability; reduced and degraded floodplain connectivity; excessive sediment input; or the loss of habitat diversity. No new facilities or construction are proposed as part of the proposed actions considered in this opinion. With the exception of the mainstem river weir (when operated), all hatchery facilities are located away from the river and its tributaries, and do not affect designated critical habitat for listed Chinook salmon and steelhead. As described above, the weir is removable, and is placed to rest on the riverbed and river bank such that Chinook salmon habitat is not adversely affected. Proposed surface water diversion for rearing juvenile salmon and the return of that water to the Dungeness River, Hurd Creek, or Gray Wolf River, will not affect the spatial distribution of adult or juvenile ESA-protected Dungeness Chinook salmon or steelhead. The programs would operate under strict Washington State water rights and NPDES permit criteria for diverting water from the river, and would not have any discernible effect on, or result in any adverse modification to critical habitat. Permitted water withdrawal levels for fish rearing are a small fraction of average annual flows in the mainstem river and tributaries where the programs are located, and water withdrawn for hatchery use is returned near the points of withdrawal. Hatchery diversion screens at Dungeness River Hatchery protect listed juvenile Chinook salmon and steelhead from entrainment and injury, and meet NMFS screen criteria (NMFS 2008a).

We do not expect adverse effects on critical habitat resulting from the fish ladder at the Canyon Creek diversion dam – in fact, when constructed, the ladder will provide anadromous fish access to several miles of potential habitat. The withdrawal of water from the diversion dam on Canyon Creek at the full Washington State water rights permit allowance of 8.5 cfs (Table 15) during the summer-fall low flow period could lead to dewatering that would adversely affect critical habitat if Chinook salmon or steelhead adults or juveniles are using the lower 530 feet of the creek. However, actual water withdrawal amounts for hatchery fish rearing during the low flow period in Canyon Creek will be much less than the permitted maximum level, because that amount of water is not required by the hatchery during that period. Fish biomass in Dungeness River hatchery, and required water withdrawal amounts, would reach the maximum permitted level only in the late winter and spring months just prior to fish release dates, when the fish are at their largest size, and flows in Canyon Creek reach the annual maximum. Water needs for the hatchery are at their lowest level during the summer and fall months, when juvenile fish biomass, and associated water supply needs, are at annual minimums. Dewatering of critical habitat for Chinook salmon and steelhead in Canyon Creek is therefore highly likely.

WDFW plans to upgrade fish screens at Hurd Creek Hatchery to ensure compliance with NMFS fish passage and screening criteria by summer 2017. For the reasons provided by WDFW in the agency's evaluation and findings regarding the current water intake and screening structure (Section 2.4.2.6; Carlson and Williams 2015), risks of adverse effects on freshwater migration corridors through entrainment of listed Chinook salmon and steelhead are unlikely to be substantial. The location of the Hurd Creek Hatchery surface water intake in an area removed from creek reaches where Chinook salmon and steelhead adults and juveniles would migrate, and the horizontal design of the intake that draws water from the bottom of a created off-channel pond, lessen the risk of listed fish injury and mortality. The water intake and screening are expected to be adequately protective of listed fish over the two year period until the structure is renovated to be in compliance with current NMFS criteria.

Effluent discharge for the hatchery operations is not expected to degrade water quality. Consistent with effluent discharge permit requirements developed by EPA and the Washington Department of Ecology (WDOE) for upland fish hatcheries, water used for fish production at Dungeness and Hurd Creek hatcheries would be adequately treated prior to discharge into downstream areas to ensure that federal and state water quality standards for receiving waters are met and that downstream aquatic life, including salmon and steelhead, are not adversely affected. Dungeness River Hatchery has a current NPDES permit (#WAG 13-1037) that requires monitoring, measurement, and monthly reporting to WDOE of water use, chemical use, and effluent discharge levels (WDFW 2013a). Fish production at Hurd Creek Hatchery, and from the Dungeness Hatchery satellite ponds (Upper Dungeness and Gray Wolf) is below annual levels for which NPDES permits are required, and for which effects on water quality and fish are of concern. The following water quality parameters, selected by EPA and WDOE as important for determining hatchery-related water quality effects, are monitored (WDFW 2013a):

- Total Suspended Solids - 1 to 2 times per month on composite effluent, maximum effluent and influent samples.
- Settleable Solids - 1 to 2 times per week through effluent and influent sampling.
- In-hatchery Water Temperature - daily maximum and minimum readings.

Consistent with the NPDES permit issued for the program, Dungeness River Hatchery releases all water used for fish rearing into an off-line settling pond and artificial wetland where settleable solids and nutrients from fish feces and uneaten food are removed before the water is discharged back into the river. WDFW reports that from 2008 through 2012, the Dungeness River Hatchery program has been in compliance with all NPDES effluent discharge permit requirements, with one exception (WDFW 2013a). In 2009, the program recorded one instance where sampling indicated the Total Suspended Solids limit in the hatchery effluent was exceeded. Because exceedance of the allowable level was the result of a natural event – high river flows and associated sediment levels led to deposition of fine sediment in the hatchery sediment pond at abnormally high levels – no remedial action was required after the incident was reported.

The other fish rearing programs at Hurd Creek Hatchery and the two upriver acclimation pond sites produce low annual levels of fish poundage well under the 20,000 pounds per year criterion set by EPA and WDOE as the limit for concern regarding hatchery effluent discharge effects and requirement for an NPDES permit. Annual fish production under 20,000 pounds per year typically produces effluent amounts that exert no more than local and transitory impacts on listed salmonids, assuming adequate mixing and dilution occur, which is the case here.

For these reasons, the proposed hatchery programs are not expected to pose substantial risks through water quality impairment to downstream aquatic life, including listed salmon and steelhead. No hatchery maintenance activities are expected to adversely modify designated critical habitat.

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 1.4. Future Federal actions, including land management activities will be reviewed through separate section 7 consultation processes

The federally approved Shared Strategy for Puget Sound recovery plan for Puget Sound Chinook Salmon (2005b), describes, in detail, the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to listed Puget Sound Chinook salmon in the Dungeness River watershed. A recovery plan for Puget Sound steelhead in the watershed has yet to be developed, but many of the actions implemented for Chinook salmon recovery will also benefit steelhead. 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. State, tribal, and local governments have developed plans and initiatives to benefit listed species (SSPS 2005b). The cumulative effects of non-Federal actions in the action area are difficult to analyze considering the geographic landscape of this opinion, the political variation in the action area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation, with the likelihood for future effects depending on the activity affecting the species, and the non-Federal entity regulating the activity. However, we expect the activities identified in the baseline to continue at similar magnitudes and intensities as in the recent past. On-going State, tribal, and local government salmon restoration and recovery actions implemented through the Shared Strategy Plan (SSPS 2005b) and through other plans and initiatives (e.g., Hood Canal Coordinating Council's Summer Chum Salmon Plan (HCCC 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. With these improvements, however, based on the trends discussed above, there is also the potential for adverse cumulative effects associated with some non-Federal actions to increase (Judge 2011). State, tribal, and local governments have developed resource use plans and initiatives to benefit listed fish and offset any growing adverse effects that are proposed to be applied and sustained in a comprehensive way (e.g., SSPS 2005b). But the actions must be reasonably certain to occur to be considered cumulative effects, and, for the reasons outlined above, they are too speculative to meet that test.

Numerous non-Federal projects and activities, funded with Federal and state dollars, are benefitting fish included in the Puget Sound Chinook Salmon ESU and Puget Sound Steelhead DPS, including populations of the species in the Dungeness River. Following the fish restoration strategies described in the Shared Strategy Plan (SSPS 2005b), in the NMFS Supplement to the recovery plan (NMFS 2006), and in the Dungeness River watershed volume of the Shared Strategy Plan (SSPS 2005a), non-Federal projects and activities have been implemented to address watershed-specific limiting factors to salmon viability. 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. Specific actions to recover listed salmon and steelhead in Puget Sound watersheds, including the Dungeness River watershed (recent examples in Section 2.3.3), have included: implementation of land use regulations to protect existing habitat and habitat-forming processes through updating and adopting Federal, state, and local land use protection programs, as well as more effectively combining regulatory, voluntary, and incentive-based protection programs; implementation of nearshore and shoreline habitat protection measures such as purchase and protection of estuary areas important for salmon productivity; protection and restoration of habitat functions in lower river areas, including deltas, side-channels, and floodplains important as rearing and migratory habitat; implementation of protective instream flow programs to reserve sufficient water for salmon production; and implementation of protective actions on agricultural lands. The effects of such activities are sometimes difficult to demonstrate in the near-term, as benefits may take varying periods of time to show an effect; to the extent that the effects of these protection and restoration actions improve the likelihood of survival and recovery of the ESA-listed species, such effects will be reflected in the species' status and abundance. Consideration of protection and restoration actions is included in the following integration and synthesis of effects.

2.6. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated critical habitat for the conservation of the species.

2.6.1. Puget Sound Chinook Salmon

After addition of the effects of the Proposed Action to the effects of all human activities in the action area, including any anticipated Federal, state, tribal, or private projects, NMFS concludes that the Proposed Action will not appreciably reduce the likelihood of survival and recovery in the wild of the Puget Sound Chinook Salmon ESU.

Based on a review of the proposed Dungeness River Hatchery program actions (Section 1.3), the status of affected Dungeness Chinook population (Section 2.2.1), and consideration of environmental baseline conditions (Section 2.3) and cumulative effects (Section 2.5), the assigned effects of the proposed salmon hatchery actions on Puget Sound Chinook salmon range from not applicable to negative (Section 2.4.2; Table 10). The viability status of the Dungeness Chinook salmon population is poor. Spawner abundance is currently critically depressed, and remaining population diversity, spatial structure, and productivity are also below desired levels required for the population to recover to a self-sustaining condition (Section 2.2.1.1). Considering its poor viability status, the Dungeness River Hatchery Chinook salmon program proposed for supportive breeding purposes is expected to benefit the Dungeness Chinook salmon population. Of the effects categories evaluated, five hatchery-related factors – Chinook salmon hatchery program effects on genetic diversity; spawning ground competition and redd superimposition effects from hatchery-origin pink salmon; juvenile hatchery-origin Chinook and coho salmon competition effects on listed juvenile Chinook salmon abundance; yearling hatchery-origin Chinook and coho salmon predation effects on listed juvenile Chinook salmon abundance; and Dungeness River Hatchery water intake structure effects on Chinook salmon migration – were assigned as potentially posing negative effects on Dungeness Chinook salmon. The remaining hatchery-related factors identified in Table 10 would have impacts that were not applicable, or negligible in magnitude (Section 2.4.2) and would not affect the viability status of the listed Dungeness Chinook salmon population.

The proposed supportive breeding program is expected to produce substantial returns of native stock adult fish that would preserve and assist in the restoration of the Dungeness Chinook salmon population to a healthy status while properly functioning habitat necessary to support a self-sustaining natural-origin population is restored (Section 2.4.2.2). In addition to these benefits, Chinook salmon produced through the hatchery program are intended to escape to natural spawning areas to help recover the abundance and spatial structure, and preserve the diversity of, the naturally spawning Dungeness Chinook salmon population. The program would likely benefit population viability parameters for the total population, and recovery of the naturally spawning population, by augmenting natural spawning abundances above levels currently achievable under degraded habitat conditions.

Genetic Effects

Although the program would benefit the viability status of the population (Section 2.4.2.2), the Dungeness River Hatchery Chinook salmon program may nonetheless pose risks to Dungeness Chinook salmon population diversity and productivity. The supportive breeding effort for the species has the potential 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 the baseline diversity and productivity status of the Dungeness Chinook salmon population serving as the donor, target stock.

Of concern regarding breeding between hatchery-origin and natural-origin Dungeness Chinook salmon are effects on the status of the natural population potentially resulting from within-population diversity reduction and hatchery-induced selection. In implementing the Dungeness River Hatchery Chinook salmon conservation program, the co-managers will follow best management practices to apply genetic risk reduction measures as part of the proposed actions (see Section 2.4.2.2). Representing best available science, NMFS expects these measures to reduce risks of substantial adverse effects that the proposed supportive breeding actions may have to a level that would not cause an appreciable reduction of the genetic diversity and fitness of the Dungeness Chinook salmon population. The co-managers will also monitor and report annual run timing, location, age and sex composition, and origin of escaping Chinook salmon to gauge changes in Chinook salmon population traits that may be associated with the supportive breeding effort. Genetic samples (DNA) will be collected from natural-origin and hatchery-origin fish used for broodstock for processing by the WDFW Molecular Genetics Lab to monitor the genetic diversity status of the population and divergence between the two aggregations (WDFW 2013a). For these reasons, the magnitude of genetic effects is likely low, and any genetic diversity and fitness loss effects are unlikely to pose substantial risks to the viability of the Dungeness Chinook population, or impede its recovery to a viable status.

Spawning Ground Interactions

Hatchery-origin pink salmon adults may spawn in the same areas where Dungeness Chinook salmon spawn, potentially leading to adverse competitive and redd superimposition effects. The concern is that pink salmon adults produced through the Dungeness River Hatchery fall-run pink salmon program may spawn in the lowest 6 miles of the Dungeness River at times and in river areas where Chinook salmon spawning may occur. Given the analysis in section 2.2.1.1, an estimated 23 Chinook salmon (approximately 12 pairs) would potentially compete with pink salmon for spawning space in odd-numbered years. Because Chinook salmon excavate, and deposit their eggs into, deeper redds on average than pink salmon (Devries 1997) detrimental redd superimposition by naturally spawning hatchery-origin pink salmon is unlikely. Further, the two species prefer different gravel sizes for spawning, which fosters separation in redd locations, decreasing the potential for adverse species interactions. Also, the fall-run pink salmon produced through the Dungeness River Hatchery program for the species return and spawn in the lowest portion of the watershed used by the Dungeness Chinook salmon population, and the majority of Chinook salmon spawning areas would not be affected. Assuming all hatchery-origin adult pink salmon fish escape to natural areas, 1,000 adult pink salmon spawning across 6 miles of mainstem river habitat, returning only in odd-numbered years, are unlikely to substantially compete for spawning areas with any Chinook salmon present, or disrupt Chinook salmon redds. Although the two species may overlap in migration and spawning times, spawning occurs in different locations within the river channel. For these reasons, this risk factor is unlikely to pose substantial risks to the viability of the Dungeness Chinook salmon population, or impede its recovery to a viable status, and on-going monitoring would make management response possible if conditions warrant.

Competition

Competition for food and habitat by newly released juvenile hatchery-origin Chinook and coho salmon may have negative effects on listed natural-origin Chinook salmon abundance and productivity in watershed areas downstream of the hatchery release sites where the hatchery-origin and natural-origin fish commingle. Adverse resource competition effects on natural-origin ESA-listed Chinook salmon associated with fall-run pink salmon releases are unlikely because of substantial size (Table 13) and, hence, prey selection differences (SIWG 1984), and the tendency of pink salmon fry to exit freshwater immediately after release. With regards to hatchery-origin Chinook and coho salmon releases, adverse effects on natural-origin Chinook salmon are possible because of shared seaward emigration timings, and similar individual smolt sizes and, therefore, similar prey preferences for the hatchery salmon and natural-origin Chinook salmon in areas downstream of hatchery release sites. To reduce freshwater competition risks to natural-origin Chinook salmon from hatchery-origin Chinook and coho salmon, practices are proposed to reduce the potential for interactions, and the duration of any interactions. All hatchery-origin Chinook and coho salmon juveniles would be released as actively migrating, seawater-ready smolts as a measure to foster rapid emigration seaward. Smolt out-migration studies in the Dungeness River indicate that most hatchery Chinook salmon emigrate rapidly downstream, and exit the river to seawater where they disperse into expansive marine areas where competition risks become negligible. The practice of releasing only actively migrating smolts, that would exit freshwater rapidly, would reduce the duration of interaction with natural-origin Chinook salmon juveniles that may be vulnerable to competition for food or space. Further, nearly all of the hatchery fish are released in the lower 10 miles of the watershed, limiting the degree and duration of interactions with the total Dungeness Chinook salmon population, which uses upstream areas accessible to anadromous fish for rearing (see Section 2.2.1.1). Hatchery and natural-origin salmon smolt emigration timing and abundance would be monitored each year through operation of a WDFW juvenile outmigrant trapping program to evaluate whether hatchery smolt release timings avoid or reduce to negligible levels, the duration of migration overlap and harmful ecological interactions with natural-origin Chinook salmon. Based on monitoring results, alternate hatchery Chinook and coho salmon release timings or other responsive risk mitigation measures would be developed to minimize such interactions. For these reasons, the magnitude of effects is likely low; hatchery fish competition is unlikely to pose substantial risks to the viability of the Dungeness Chinook population, or impede its recovery to a viable status, and on-going monitoring would make management response possible if conditions warrant. NMFS will monitor emerging science and information related to interactions between hatchery steelhead and fish from natural populations, and will consider whether re-initiation of consultation is required in the event that new information regarding hatchery fish competition reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

Predation

Considering natural fish occurrence and proposed hatchery-origin fish life stage and release timings into the Dungeness River where predator-prey interactions would potentially occur, the hatchery-origin species and life stages with substantial spatial and temporal overlap with juvenile listed Chinook salmon of life stages and sizes vulnerable to predation would be yearling Chinook and coho salmon. Chinook salmon yearlings released in April into Hurd

Creek would be of large enough size to prey on juvenile Chinook salmon less than approximately 50 mm fork length present in the lower Dungeness River when the hatchery fish would be released. Although of similarly large size at the time of their release, hatchery-origin coho salmon yearlings would be released in mid-May, when the majority of co-occurring natural-origin Chinook salmon would generally be too large to be vulnerable to predation (Table 13). Subyearling Chinook salmon and pink salmon fry released through the proposed programs would not pose risks of predation to natural-origin Chinook salmon due to size similarities and diet preferences that make predation unlikely. The proposed programs for yearling Chinook and coho salmon would apply several measures to reduce the potential for predation on listed juvenile Chinook salmon. All hatchery-origin Chinook salmon yearlings would be released as migration-ready smolts directly from Hurd Creek Hatchery, which is located in the lowest portion of the river (RM 2.7). All hatchery-origin coho salmon yearlings would be released as migration-ready smolts into the Dungeness River from Dungeness River Hatchery at RM 10.5. These release sites minimize the areal extent where any co-occurring natural-origin fish would be exposed to interactions with the yearling hatchery fish. All hatchery fish would be released as migration-ready smolts that have been shown through juvenile out-migrant trapping studies (Topping et al. 2006) to quickly emigrate downstream from the lower Dungeness River where they would disperse into marine waters, minimizing the duration of interaction with any natural-origin salmonids of a size vulnerable to predation. There will be few natural-origin fish of any species in the lower Dungeness River that would serve as prey for hatchery-origin yearlings when and where proposed juvenile fish releases would occur due to the currently depressed status of listed fish populations in the watershed. Juvenile out-migrant monitoring would continue in the lower watershed to determine annual salmonid size and emigration timing by species and origin, and to identify spatial and temporal overlap between hatchery-origin Chinook and coho salmon yearlings and natural-origin Chinook salmon. The release programs for hatchery yearlings could be revised if juvenile out-migrant monitoring in the Dungeness River indicates that release timings result in substantial overlap with, and associated predation risks for, listed natural-origin fish of sizes vulnerable to predation. For these reasons, the magnitude of effects is likely low; hatchery yearling predation is unlikely to pose substantial risks to the viability of the Dungeness Chinook population, or impede its recovery to a viable status, and on-going monitoring would make management response possible if conditions warrant. NMFS will monitor emerging science and information related to interactions between hatchery fish and fish from natural populations and will consider whether re-initiation of consultation is required in the event that new information regarding predation by hatchery fish reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

Water Intake Effects

Hatchery operation and maintenance activities may pose risks to listed Chinook salmon abundance. The water intake and associated screens used for the three Dungeness River Hatchery programs may not be adequately protective of juvenile fish from entrainment and injury (Section 2.4.2.6). Although the water intake screens on the Dungeness River and Canyon Creek are in compliance with state and federal guidelines (NMFS 1995; NMFS 1996), they do not currently meet current NMFS Anadromous Salmonid Passage Facility Design Criteria (NMFS 2011b). WDFW is in the process of correcting fish passage problems at the location of the Dungeness River and Canyon Creek water intake structures, with plans to complete work by fall 2019 and fall 2017, respectively. The current three structures used to withdraw water from the Dungeness River will be reduced to one structure, which will be passable to upstream and downstream migrating fish (WDFW 2013a).

When renovated, the Dungeness River mainstem structure will not likely pose substantial fish passage risks to migrating juvenile and adult salmon. Currently, operation of the mainstem water intakes has not been observed to block fish passage or result in any mortality events, even though it is out of compliance with current NMFS (2011b) fish passage criteria. The current water intakes on the Dungeness River mainstem meet NMFS previous screening criteria (NMFS 2008a), and NMFS (2011b) states that such screening is adequately protective of listed Chinook salmon from impingement and entrainment effects until the structures are renovated, when at that time, they must meet current NMFS screening criteria (NMFS 2011b). WDFW will ensure that screening on the new water intake is in compliance with the latest NMFS criteria when construction is completed.

With regards to the Canyon Creek water intake, a ladder will be constructed by fall 2017 in the dam that impounds water for periodic (winter only) use by the hatchery so that the structure is passable to migrating fish (WDFW 2013a: A. Carlson, WDFW, pers. comm., April 24, 2015). Through a separate NMFS ESA consultation (NMFS 2013b), effects of the construction of the fish ladder to allow unimpeded upstream and downstream passage for salmon, steelhead, and bull trout were found not likely to adversely affect ESA-listed salmon and steelhead. NMFS's approval of the ladder construction was designed so that the hatchery water intake structure on Canyon Creek will be brought into compliance with NMFS fish passage criteria (NMFS 2011b). Currently, the structure impedes passage but, because of the small proportion of habitat represented by the area in Canyon Creek upstream of the dam, not at a level that affects viability. When construction results in additional accessible habitat in Canyon Creek, the water intake will not result in dewatering of the stream and will result in minimized effects at the intake structure itself.

WDFW plans to upgrade fish screens at Hurd Creek Hatchery to ensure compliance with NMFS fish passage criteria by summer 2017. An evaluation of the Hurd Creek Hatchery surface water intake screen by WDFW indicates adverse effects on any migrating salmonids are unlikely (Carlson and Williams 2015). For the reasons provided by WDFW in the agency's evaluation and findings regarding the current water intake and screening structure (Section 2.4.2.6.; Carlson and Williams 2015), risks of entrainment and mortality of listed Chinook salmon are not likely to affect the viability status of the Dungeness Chinook population. The location of the Hurd Creek Hatchery surface water intake in an area removed from creek reaches where Chinook salmon adults and juveniles would migrate, and the horizontal design of the intake that draws water from the bottom of a created off-channel pond, substantially reduce the risk of listed fish injury and mortality. The water intake and screening are expected to be adequately protective of listed fish over the two-year period until the structure is renovated to be in compliance with current NMFS criteria.

Withdrawal of surface water at maximum permitted levels for fish rearing could decrease the quantity of water available for Chinook salmon migration and rearing, potentially leading to adverse effects. However, adverse effects on Chinook salmon are unlikely, because water withdrawal amounts for hatchery fish rearing during the summertime low flow periods, when any effects would be most pronounced, will be much less than the permitted maximum levels. Fish biomass at the hatchery rearing locations, and required water withdrawal amounts, would reach the maximum permitted levels (Table 15) only in the late winter and spring months just prior to fish release dates, when the fish are at their largest size, and flows in the Dungeness River, Canyon Creek, and Hurd Creek reach annual maximums (Figure 11). Hatchery water needs are at their lowest level during the summer and fall months, when juvenile fish biomass, and associated water supply needs, are at annual minimums. For these reasons, the magnitude of effects on listed Chinook salmon associated with hatchery operation and maintenance actions is likely low; the proposed actions are unlikely to pose substantial risks to the viability of the Dungeness Chinook population, or impede its improvement to a viable status, and on-going monitoring would make management response possible if conditions warrant.

Summary of Effects on Chinook Salmon

The Federally approved Recovery Plan for Puget Sound Chinook salmon (Ruckelshaus et al. 2005; SSPS 2005b) identified primary limiting factors and threats to the Dungeness Chinook salmon population, including degraded nearshore and estuarine habitat; degraded freshwater habitat; anadromous salmonid hatchery programs operated for harvest augmentation purposes; and salmon harvest management effects on weak Chinook salmon populations (Section 2.2.1). None of these factors will be affected, in a measureable way, by the proposed action. This analysis has considered recovery planning documents and the potential effects of the proposed action on the Puget Sound Chinook Salmon ESU, combined with other past and ongoing activities inside the action area, including implementation of protective harvest management actions (Section 2.3.1), the effects of past hatchery operations (Section 2.3.2), and habitat protection and restoration projects implemented to benefit ESU viability (Section 2.3.3). This analysis leads to a determination that the proposed action will not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the ESU.

Taken together, the effects of the proposed action are expected to benefit the Puget Sound Chinook salmon ESU. Even accounting for the negative effects described above, the benefit to abundance provided by the hatchery program at this time when natural-origin abundance is critically low will reduce the risk of extirpation of this important population and its genetic legacy. Over time, as Dungeness Chinook population abundance rises, any adverse effects resulting from hatchery-related genetics, competition, predation, and operation and maintenance impacts will decrease as natural-origin returns become a larger and larger percentage of the total spawning population, both in the wild and in the hatchery broodstock.

2.6.2. Puget Sound Steelhead

After addition of the effects of the Proposed Action to the effects of all human activities in the action area, including any anticipated Federal, state, tribal, or private projects, NMFS concludes that the Proposed Action will not appreciably reduce the likelihood of survival and recovery in the wild of the Puget Sound steelhead DPS.

Based on a review of the proposed Dungeness River Hatchery program actions (Section 1.3), the status of affected Dungeness River steelhead population (Section 2.2.1), and consideration of environmental baseline conditions (Section 2.3) and cumulative effects (Section 2.5), the assigned effects of the proposed salmon hatchery actions on Puget Sound steelhead range from not applicable to negative (Section 2.4.2; Table 10). The viability status of the Dungeness River steelhead population is poor. Like Chinook salmon in the river, annual spawner abundance is depressed, and current remaining population diversity, spatial structure, and productivity are below desired levels required for the population to recover to a self-sustaining condition (Section 2.2.2.1). Of the effects categories evaluated, three hatchery-related factors – hatchery-origin Chinook and coho salmon competition with juvenile steelhead; yearling hatchery-origin Chinook and coho salmon predation on juvenile steelhead; and Dungeness River Hatchery program water intake structure effects on steelhead migration – were identified as potentially posing adverse effects on Dungeness River steelhead (see Section 2.4.2.6). The remaining hatchery-related factors identified in Table 10 would have effects that were not applicable, or negligible in effects magnitude (Section 2.4.2) and would not affect the viability status of the listed Dungeness steelhead population.

Competition

Competition for food and habitat by newly released juvenile hatchery-origin Chinook and coho salmon may have negative effects on listed natural-origin steelhead abundance and productivity in watershed areas downstream of the hatchery release sites where the hatchery-origin and natural-origin fish commingle. However, the extent of competition effects on natural-origin ESA-listed steelhead associated with fall-run pink salmon releases is unlikely to be more than minimal, because of substantial size (Table 13) and prey selection differences (SIWG 1984), and the tendency of pink salmon fry to exit freshwater immediately after release.

Adverse competition effects on natural-origin steelhead juveniles are possible as a result of hatchery-origin Chinook and coho salmon releases, because the species have shared seaward emigration timings, and similar individual smolt sizes and hence similar prey preferences in areas downstream of hatchery release sites (Table 13). Because all hatchery-origin Chinook and coho salmon juveniles would be released as actively migrating, seawater-ready smolts as a measure to foster rapid emigration seaward, such adverse effects would be minimized. Smolt out-migration studies in the Dungeness River indicate that most hatchery Chinook salmon emigrate rapidly downstream, and exit the river to seawater where they disperse into expansive marine areas where competition risks become negligible (Topping et al. 2006). The practice of releasing only actively migrating smolts, which would exit freshwater rapidly, would reduce the duration of interaction with natural-origin steelhead juveniles that may be vulnerable to competition for food or space. Further, nearly all of the hatchery fish are released in the lower 10 miles of the watershed, limiting the degree and duration of interactions with the total Dungeness River juvenile steelhead population, which predominantly uses upstream areas accessible to anadromous fish for rearing.

Hatchery and natural-origin salmon and steelhead smolt emigration timing and abundance would be monitored each year through operation of a WDFW juvenile out-migrant trapping program. This program would help evaluate whether hatchery smolt release timings avoid, or reduce to negligible levels, the duration of migration overlap and harmful ecological interactions with natural-origin steelhead. Based on monitoring results, alternate hatchery Chinook and coho salmon release timings or other responsive risk mitigation measures would be developed to minimize such interactions.

For these reasons, the magnitude of effects is likely low; hatchery fish competition is unlikely to pose substantial risks to the viability of the Dungeness River steelhead population, or impede its recovery to a viable status, and on-going monitoring would make management response possible if conditions warrant. NMFS will monitor emerging science and information related to interactions between hatchery steelhead and fish from natural populations, and will consider whether re-initiation of consultation is required in the event that new information regarding hatchery fish competition reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

Predation

Considering natural fish occurrence and proposed hatchery-origin fish life stage and release timings into the Dungeness River where predator-prey interactions would potentially occur, the hatchery-origin species and life stages with substantial spatial and temporal overlap with juvenile listed steelhead of life stages and sizes vulnerable to predation would be yearling Chinook and coho salmon. Chinook salmon yearlings released in April and coho salmon yearlings released in May would be of large enough size to prey on any juvenile steelhead less than approximately 50 mm fork length in size present in Hurd Creek or the lower Dungeness River. (Subyearling Chinook salmon and pink salmon fry released through the proposed programs would not pose risks of predation to natural-origin steelhead due to their relatively small size, tendency to exit freshwater immediately after release, and diet preferences that make fish predation unlikely.)

The proposed programs for yearling Chinook and coho salmon would apply several measures to reduce the potential for predation on juvenile steelhead. All hatchery-origin Chinook salmon yearlings would be released as migration-ready smolts directly from Hurd Creek Hatchery, which is located in the lowest portion of the river (RM 2.7). All hatchery-origin coho salmon yearlings would be released as migration-ready smolts into the Dungeness River from Dungeness River Hatchery at RM 10.5. These release sites minimize the areal extent where any co-occurring natural-origin steelhead would be exposed to interactions with the yearling hatchery fish. All hatchery fish would be released as migration-ready smolts that have been shown through juvenile out-migrant trapping studies (Topping et al. 2006) to quickly emigrate downstream from the lower Dungeness River where they would disperse into marine waters, minimizing the duration of interaction with any natural-origin steelhead of a size vulnerable to predation.

There will be few natural-origin steelhead juveniles in the lower Dungeness River that would serve as prey for hatchery-origin yearlings when and where proposed juvenile fish releases would occur, due to the currently depressed status of listed steelhead in the watershed and the tendency for steelhead to spawn and rear as juveniles in upper watershed areas. Juvenile out-migrant monitoring would continue in the lower watershed to determine annual salmonid size and emigration timing by species and origin, and to identify spatial and temporal overlap between hatchery-origin Chinook and coho salmon yearlings and natural-origin steelhead. The release programs for hatchery yearlings could be revised if juvenile out-migrant monitoring in the Dungeness Rivers indicates that practiced release timings result in substantial overlap, and associated predation risks, for steelhead of sizes vulnerable to predation.

For these reasons, the magnitude of effects is likely low; hatchery yearling predation is unlikely to pose substantial risks to the viability of the Dungeness River steelhead population, or impede its recovery to a viable status, and on-going monitoring would make management response possible if conditions warrant. NMFS will monitor emerging science and information related to interactions between hatchery fish and fish from natural populations and will consider whether re-initiation of consultation is required in the event that new information regarding hatchery fish predation reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

Water Intake Effects

Hatchery operation and maintenance activities may pose risks to listed steelhead of the same types and at the same magnitudes as described above for Chinook salmon. The water intake and associated screens used for the three Dungeness River Hatchery programs may not be adequately protective of juvenile fish from entrainment and injury (Section 2.4.2.6). Although the water intake screens on the Dungeness River and Canyon Creek are in compliance with state and federal guidelines (NMFS 1995; 1996), they do not currently meet current NMFS Anadromous Salmonid Passage Facility Design Criteria (WDFW 2013a). WDFW is in the process of correcting fish passage problems at the location of the Dungeness River and Canyon Creek water intake structures, with plans to complete work by fall 2019 and fall 2017, respectively. The current three structures used to withdraw water from the Dungeness River will be reduced to one structure, which will be passable to upstream and downstream migrating fish (WDFW 2013a). When renovated, the Dungeness River mainstem structure will not likely pose substantial fish passage risks to migrating juvenile and adult salmon. Although out of compliance with current NMFS (2011b) fish passage criteria, no fish passage problems or fish mortality events have been observed during operation of the mainstem water intakes. The current water intakes on the Dungeness River mainstem meet NMFS previous screening criteria (NMFS 2008a), and NMFS (2011b) states that such screening is adequately protective of listed steelhead from impingement and entrainment effects until the structures are renovated, at which time they must meet current NMFS screening criteria (NMFS 2011b). WDFW will ensure that screening on the new water intake is in compliance with the latest NMFS criteria when construction is completed.

With regards to the Canyon Creek water intake, by fall 2017, a ladder will be constructed in the dam that impounds water for periodic (winter only) use by the hatchery, so that the structure is passable to migrating fish (WDFW 2013a: A. Carlson, WDFW, pers. comm., April 24, 2015). Through a separate NMFS ESA consultation (NMFS 2013b), effects of the construction of the fish ladder to allow unimpeded upstream and downstream passage for salmon, steelhead, and bull trout were found not likely to adversely affect ESA-listed salmon and steelhead. NMFS' approval of the ladder construction was designed so that the hatchery water intake structure on Canyon Creek will be brought into compliance with NMFS fish passage criteria (NMFS

2011b). Currently, the structure impedes steelhead passage but, because of the small proportion of habitat represented by the area in Canyon Creek upstream of the dam, not at a level that affects viability. When construction results in additional accessible habitat in Canyon Creek, the water intake and associated dam will not result in dewatering of the stream and will be result in minimized effects at the intake structure itself.

WDFW plans to upgrade fish screens at Hurd Creek Hatchery to ensure compliance with NMFS fish passage criteria by summer 2017. For the reasons provided by WDFW in the agency's evaluation and findings regarding the current water intake and screening structure (Section 2.4.2.6; Carlson and Williams 2015), risks of entrainment and mortality to listed steelhead are not likely to affect the viability status of the Dungeness River steelhead population. The location of the Hurd Creek Hatchery surface water intake in an area removed from creek reaches where steelhead adults and juveniles would migrate, and the horizontal design of the intake that draws water from the bottom of a created off-channel pond, adequately lessen the risk of substantial listed steelhead injury and mortality. The water intake and screening are expected to be adequately protective of listed fish over the two-year period until the structure is renovated to be in compliance with current NMFS criteria. Withdrawal of surface water at maximum permitted levels for fish rearing could decrease the quantity of water available for steelhead migration and rearing, potentially leading to adverse effects. Adverse effects on steelhead are unlikely, because water withdrawal amounts for hatchery fish rearing during the summertime low flow periods when any effects would be most pronounced will be much less than the permitted maximum levels (Table 15). Fish biomass at the hatchery rearing locations, and required water withdrawal amounts, would reach the maximum permitted levels only in the late winter and spring months just prior to fish release dates, when the fish are at their largest size, and flows in the Dungeness River, Canyon Creek, and Hurd Creek reach annual maximums (Figure 11). Hatchery water needs are at their lowest level during the summer and fall months, when juvenile fish biomass, and associated water supply needs, are at annual minimums. Dewatering of critical habitat for steelhead in the action area, and adverse effects on listed steelhead are therefore highly likely. For these reasons, the magnitude of effects on listed steelhead associated with hatchery operation and maintenance actions are likely low, and the proposed actions are unlikely to pose substantial risks to the viability of the Dungeness River steelhead population, or impede its recovery to a viable status.

Summary of Effects on Steelhead

A Federally approved recovery plan for Puget Sound steelhead has not yet been completed. A recent ESA status review of the Puget Sound steelhead DPS identified primary limiting factors and threats to the Dungeness River steelhead population, including the continued destruction and modification of steelhead habitat (the principal factor limiting DPS viability); widespread declines in total adult run size abundances; threats to DPS diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania); declining DPS population diversity; reduction in DPS spatial structure; reduced freshwater habitat quality; gravel scour, bank erosion, and sediment deposition from urban development, increased flood frequency and peak flows during storms, and reduced groundwater-driven summer flows; and reduced river braiding and sinuosity from dikes, hardening of banks with riprap, and channelization (Section 2.2.2.1). The proposed action will not adversely affect any of these factors in a measureable way. This analysis has considered limiting factors identified for the listed DPS and the potential effects of the proposed action on the Puget Sound Steelhead DPS, combined with other past and ongoing activities inside the action area, including implementation of conservative harvest management actions (Section 2.3.1), the effects of past hatchery operations (Section 2.3.2), and habitat protection and restoration projects implemented to benefit DPS viability (Section 2.3.3). This analysis leads to a determination that the proposed action will not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the DPS.

Taken together, the proposed actions are expected to have a negligible effect on the Puget Sound Steelhead DPS. Even accounting for the negative effects described above, measures implemented to reduce salmon hatchery-related ecological and demographic effects are based on best management practices that are expected to adequately minimize risks to listed steelhead to levels that do not adversely impact viability. Improvements in the viability status of the Dungeness River steelhead population resulting from implementation of fish habitat restoration actions in the watershed (Section 2.3.3) will further reduce the magnitude of any effects as steelhead abundance increases and distribution within the upper watershed above hatchery salmon release locations expands.

2.6.3. Critical Habitat

Critical habitat for ESA-listed Puget Sound Chinook salmon and Puget Sound steelhead are described in Sections 2.2.1.2 and 2.2.2.2 of this opinion. In reviewing the proposed action and evaluating its effects, NMFS has determined that the proposed action will not degrade habitat designated as critical for listed fish spawning, rearing, juvenile migration, and adult migration purposes.

The mainstem water intake structures used by Dungeness River Hatchery on the mainstem Dungeness River and in Hurd Creek Hatchery as currently designed do not pose substantial risks to critical habitat associated with upstream and downstream anadromous fish access. Screening at both sites is in compliance with NMFS (2005) and NMFS (2006) screening criteria, and water intakes used are in the process of being replaced or renovated so that they will be in compliance with current NMFS fish passage and screening criteria (NMFS 2011b). For the interim period, the intake structures at the two locations are expected to pose only low and unsubstantial risks to on Chinook salmon and steelhead critical habitat in the action area (Section 2.4.2.6). Under current conditions, the water intake structure on Canyon Creek adversely affects anadromous fish access to critical habitat for Chinook salmon and steelhead. As reviewed and approved through a separate NMFS ESA consultation (NMFS 2013b), WDFW will, by fall 2017, construct a ladder in the dam on Canyon Creek that impounds water for periodic (winter only) use by the hatchery so that the structure is passable to migrating fish. Through that separate NMFS ESA consultation, effects of the construction of the fish ladder to allow unimpeded upstream and downstream passage for salmon, steelhead, and bull trout were found not likely to adversely affect critical habitat designated under the ESA. NMFS' approval of the ladder construction is designed so that the hatchery water intake structure on Canyon Creek no longer affect critical habitat. For the interim period, the area of Canyon Creek upstream of the current water intake structure represents a very small proportion (approximately 1.6 miles) of the total amount of habitat available to Chinook salmon and steelhead in the action area. Further, only some of the area upstream of the water intake is suitable habitat for salmonid spawning and rearing (NMFS 2013b).

Withdrawal of surface water at maximum permitted levels for fish rearing could decrease the quantity of water available for salmon and steelhead migration and rearing between hatchery water intake and water discharge points, potentially leading to adverse effects on designated critical habitat. Adverse effects on critical habitat are unlikely, because water withdrawal amounts for hatchery fish rearing during the summertime low flow periods when any effects would be most pronounced will be much less than the permitted maximum levels. Fish biomass at the hatchery rearing locations, and required water withdrawal amounts, would reach maximum permitted levels only in the late winter and spring months just prior to fish release dates, when the fish are at their largest size, and flows in the Dungeness River, Canyon Creek, and Hurd Creek reach annual maximums. Hatchery water needs are at their lowest level during the summer and fall months, when juvenile fish biomass, and associated water supply needs, are at annual minimums. Dewatering of critical habitat for salmon and steelhead in the action area that may lead to substantial effects is therefore highly likely.

There are no other activities included as part of the proposed action that could substantially affect critical habitat. Existing hatchery facilities, including the mainstem and tributary water intake structures, have not led to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity. Further, no new facilities or changes to existing facilities other than the water intake structures are proposed. The proposed action includes strict criteria for withdrawing and discharging water used for fish rearing. Together, these actions will not have any discernible adverse effect on critical habitat, instead resulting in measurable, albeit small, improvements in habitat quality.

2.6.4. Climate Change

The Dungeness River Chinook salmon and steelhead populations may be adversely affected by climate change (see Section 2.2.3). A decrease in winter snow pack resulting from predicted rapid changes over a geological scale in climate conditions on the Olympic Peninsula would be expected to reduce spring and summer flows, impairing water quantity and water quality in primary fish rearing habitat located in the mainstem Dungeness River and the Gray Wolf River. Predicted increases in rain-on-snow events would increase the frequency and intensity of floods in the mainstem river, leading to scouring flows that would threaten the survival and productivity of natural-origin listed fish species. The proposed Dungeness River Hatchery Chinook salmon program is expected to help attenuate these impacts over the short term by providing a refuge from adverse effects for the propagated species through circumvention of potentially adverse migration, natural spawning, incubation, and rearing conditions. Additional access to several miles of Canyon Creek by the construction of a fish ladder may also provide a small buffer to climate effects by providing additional spawning and rearing capacity.

2.7. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the Puget Sound Chinook Salmon ESU or the Puget Sound Steelhead DPS or destroy or adversely modify their 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 222.102). "Incidental take" is defined as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 DFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited under the ESA if that action is performed in compliance with the terms and conditions of this Incidental Take Statement.

2.8.1. Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take would occur as follows:

NMFS analyzed eight factors applicable to the proposed hatchery salmon actions. Five factors analyzed are likely to result in take of listed Puget Sound Chinook salmon: Chinook salmon hatchery program effects on genetic diversity; spawning ground competition and redd superimposition effects from hatchery-origin pink salmon; juvenile hatchery-origin Chinook and coho salmon competition effects on listed juvenile Chinook salmon abundance; yearling hatchery-origin Chinook and coho salmon predation effects on listed juvenile Chinook salmon abundance; and Dungeness River Hatchery water intake structure effects on Chinook salmon migration. Three factors are likely to result in take of listed Puget Sound steelhead: juvenile hatchery-origin Chinook and coho salmon competition effects on juvenile steelhead; yearling hatchery-origin Chinook and coho salmon predation on juvenile steelhead; and Dungeness River Hatchery water intake structure effects on steelhead migration.

Take during broodstock collection

Up to 112 ESA-listed Puget Sound Chinook salmon adults would be intentionally collected, retained, spawned, and killed for use as broodstock in the supportive breeding program for the Dungeness population. They would be taken as voluntary returns to the Dungeness Hatchery and, as needed to complete the target take, at the mainstem weir and trap and through opportunistic gillnetting and gaffing. To account for unintentional mortality resulting from broodstock collection methods applied, up to 18 adults in addition to the 112 adults required to produce progeny at annual program goal levels may be taken each year (total take of 130 adult fish).

As stated above, WDFW reported that a total of 21 adult steelhead of either natural- or hatchery-origin were trapped and released while collecting broodstock for the Dungeness River Hatchery Chinook salmon program in 2011. Prior to that year, no steelhead had been trapped during Chinook salmon broodstock collection operations for 5 years (WDFW 2013a). In 2011, broodstock collection started prior to May, when winter-run kelts leaving the Dungeness River for seawater, or summer-run fish that strayed as "dip-ins" into the river from other watersheds are more likely to be encountered. Because the proposed Chinook salmon plan calls for broodstock collection to begin after May 1, encounters with steelhead during Chinook salmon broodstock collection are not expected, any native-stock steelhead captured would be immediately released. However, assuming the worst case, to account for potential incidental take resulting from Chinook salmon broodstock collection, up to 30 steelhead may be taken each year through capture, handling, release, and, potentially, mortality.

Take by genetic effects

Implementation of the Dungeness River Hatchery Chinook salmon program has the potential to result in some degree of genetic change and fitness reduction in hatchery fish produced through the program, in the progeny of naturally spawning hatchery fish, and in the natural population relative to the baseline diversity and productivity status of the Dungeness Chinook salmon population. The entire listed Chinook salmon population in the Dungeness River may experience these genetic effects. Consistent with the integrated conservation intent of the proposed supportive breeding effort, listed Chinook salmon adults would be taken into the hatchery as broodstock, exposing the propagated component of the population to hatchery-influenced genetic effects. Fish produced by the program would also escape to spawn naturally in areas where hatchery-origin and natural-origin will commingle at high hatchery-origin spawner proportions, potentially leading to unintended genetic effect through interbreeding.

It is not possible to ascertain the exact amount of take by genetic effects related to hatchery fish spawning naturally, because it is not possible to meaningfully measure the number of interactions, nor their precise effects. Therefore, NMFS will rely on a surrogate take indicator that relates to the productivity of the listed population – a primary factor in determining genetic diversity and fitness reduction effects. It should be noted that the productivity goals may go unmet for a variety of factors apart from hatchery-related genetic effects (most notably, the degraded state of freshwater habitat in the basin, and the effects of climate change on ocean productivity), but the selected indicator would trigger further analysis to determine the causes of low productivity, with effects attributed to the hatchery program considered commensurately with other factors (e.g., habitat-related conditions and harvest-related effects). NMFS will rely on the estimated recruits per spawner (R/S) rate averaged over five consecutive years as a surrogate take indicator that relates to the productivity of the listed Chinook salmon population. The 1999-2008 estimated average R/S rate for the Dungeness Chinook salmon population is 0.7 (NMFS 2013a) (see Section 2.2.1.1), so NMFS will apply a rate of 0.7 recruits per spawner, averaged over five consecutive years as the surrogate take indicator.

In applying this take surrogate, NMFS assumes that the condition of freshwater and estuary habitat in the Dungeness River watershed is stable or in the process of recovery as a result of habitat restoration actions. NMFS also assumes that the productivity status of the ocean where Chinook salmon predominantly rear does not differ markedly from average conditions observed in recent years. Failure to maintain an average population productivity at the 0.7 R/S level or greater for five consecutive years would indicate that NMFS' conclusion that hatchery-related genetic effects are not a key limiting factor would merit reconsideration.

Using a five-year average is appropriate in this instance; a five-year consecutive adult return span, encompassing the full number of brood lines, is the minimum number of return years needed to appropriately estimate the productivity status of the population, given that adults primarily return at four and five years of age (Section 2.2.1.1). Further, as acknowledged above, a variety of other factors could also – separately from any genetic effects attributable to the hatchery program – cause the R/S rate to fall below 0.7, but use of a five-year average would tend to account for short-term, small-scale variability, and longer-term factors (such as those resulting from climate change) that would be detected as trends requiring consideration in the future. Generally, then, NMFS assumes that not meeting the five-year R/S objective can reasonably lead to productive consideration of the efficacy of the proposed action's performance and associated genetic effects. If at any time the R/S rate drops low enough so that the subsequent five-year average cannot reasonably be expected to reach 0.7, NMFS will act immediately rather than waiting for the five years to run.

Assessment of annual achievement of these R/S values should not commence using data prior to 2021, when the first five-year-old adult returns resulting from implementation of the proposed Chinook salmon hatchery actions considered in this opinion will escape to the Dungeness River watershed. It would not be appropriate to use R/S values prior to 2021 to evaluate effects on productivity of the proposed action, because R/S values in the two years before 2021 would reflect results of hatchery activities to produce juvenile and adult fish conducted prior to implementation of the proposed action – that is, they would reflect the effects of hatchery activities before this HGMP imposed changes to further reduce potential listed fish effects. Therefore, prior to 2021 NMFS will rely on a different surrogate to determine the extent of incidental take.

For years prior to 2021, the surrogate take indicator on which NMFS will rely is a natural-origin 0+ Chinook egg-to-migrant survival rate and annual peak incubation flow relationship similar to the one observed in recent years (brood years 2004-2014). Specifically, to address potential productivity effects for brood years returning prior to 2021, NMFS expects annual natural-origin 0+ Chinook egg-to-migrant predicted survival rates versus annual peak incubation flow to be no greater than two standard deviations (3.53%) below the rate predicted using the relationship described in Figure 4. For any year prior to 2021, if the estimated natural-origin 0+ Chinook egg-to-migrant survival rate drops two standard deviations below the predicted rate for the observed peak incubation flow, NMFS will reconsider its conclusion that hatchery-related effects on Chinook salmon population fitness is not a limiting factor. This is a logical short-term surrogate indicator of incidental take because substantial changes in this relationship showing survival levels below those predicted at given peak incubation flows indicate poor spawner performance, potentially reflecting hatchery-related fitness loss effects.

Productivity over the near-term and long-term periods will be monitored by the co-managers by comparing estimated adult Chinook salmon escapement to natural spawning areas in the Dungeness River watershed with escapement estimates for the resultant returning spawner brood years. Estimates of total adult recruitment to fisheries harvest, as modeled by the Fishery Regulation Assessment Model (FRAM) used by the PFMC, plus the estimated escapement levels, would be used to estimate total recruitment for resultant progeny brood years. Egg-to-migrant survivals will be measured annually. Additionally, R/S values can be reliably monitored through analysis of annual spawning ground survey, biological sampling, and mark recovery data collected to estimate the number of naturally spawning fish by age and origin.

Take by spawning ground superimposition and competition

Implementation of the Dungeness River Hatchery pink salmon program may lead to the take of ESA-listed Chinook salmon through spawning ground competition and redd superimposition effects. The two species select different gravel sizes and river areas for spawning, and pink salmon spawning will be largely confined to the lower six miles of the Dungeness River, downstream of reaches where the majority of Chinook salmon returning to the river spawn naturally each year. Therefore, NMFS expects no more than 40% of adults from the ESA-listed Chinook salmon population to potentially experience take in the form of spawning ground competition or redd superimposition, based on recent production and adult survival levels—at present, that number is approximately 23 adults (12 pairs) This take can be reliably monitored by spawning ground surveys to track incidences of hatchery pink salmon displacing or adversely affecting listed Chinook salmon through these pathways.

Take in the form of delayed or displaced natural spawning resulting from co-manager surveys for spawner distribution and for redd superimposition is not expected (take resulting from surveys are already authorized through a separate NMFS consultation on WDFW research, monitoring and evaluation programs (NMFS 2015b)).

Take by juvenile hatchery-origin fish competition

NMFS has determined that juvenile hatchery-origin Chinook and yearling coho salmon compete with rearing and migrating natural-origin Chinook salmon and steelhead in freshwater areas downstream of the release sites. As described in Section 2.4.2.3, hatchery-origin Chinook and coho salmon may overlap spatially and temporally with natural-origin Chinook salmon and steelhead juveniles, potentially leading to competition for food and space for the period before the hatchery fish exit the Dungeness River seaward. To reduce the risk of spatial and temporal overlap between juvenile hatchery-origin and listed natural-origin fish that might lead to competition effects, hatchery management practices would be implemented to minimize the duration of interaction between newly released hatchery-origin Chinook salmon and yearling coho salmon and natural-origin Chinook salmon and steelhead.

It is not possible to quantify the take associated with competition in the action area, because it is not possible to meaningfully measure the number of interactions between hatchery-origin these hatchery-origin species and life stages and natural-origin Chinook salmon and steelhead juveniles. Therefore, NMFS will rely on a surrogate take indicator that relates to the proportion of the total abundance of emigrating juvenile salmonids comprised of hatchery-origin Chinook salmon or coho salmon in the lower Dungeness River for the period after the hatchery fish are released. The surrogate take indicator is a proportion of all hatchery- and naturally-produced juvenile salmon and steelhead emigrating seaward in the Dungeness River downstream of the hatchery release sites on or after the 10^{th} day after the last release of the hatchery-origin Chinook salmon and coho salmon, respectively, that is represented by hatchery-origin Chinook salmon or coho salmon; this proportion should remain smaller than 10 percent.

The proportion of hatchery-origin Chinook salmon or coho salmon versus total juvenile fish abundance will be calculated by statistical week, commencing the fourth week post-hatchery release and continuing until no hatchery-origin Chinook salmon and coho salmon are captured, as identified either through expanded estimates or catch per unit effort (CPUE). This standard has a rational connection to the amount of take expected from ecological effects, since the co-occurrence of hatchery-origin and natural-origin fish is a necessary pre-condition to competition, and the assumption that, the greater ratio of hatchery fish to natural-origin fish, the greater likelihood that competition will occur. This proportion of hatchery fish in the rearing areas will be monitored by standing co-manager juvenile out-migrant screw trap monitoring activities.

Take by juvenile hatchery-origin fish predation

In its evaluation, NMFS has determined that yearling hatchery-origin Chinook and coho salmon could prey on rearing and migrating natural-origin juvenile Chinook salmon and steelhead in freshwater areas downstream of the release sites. As described in Section 2.4.2.3, yearling Chinook and coho salmon released from Dungeness River Hatchery and Hurd Creek Hatchery have substantial spatial and temporal overlap with juvenile listed Chinook salmon and steelhead of sizes vulnerable to predation. To reduce the risk of spatial and temporal overlap with listed natural-origin Chinook salmon and steelhead that might lead to predation effects, hatchery management practices would be implemented to minimize the duration of interaction between newly released yearling Chinook salmon and yearling coho salmon and the natural-origin juveniles.

It is not possible to quantify the take associated with predation in the action area, because it is not possible to meaningfully measure the number of interactions between the hatchery-origin yearlings and natural-origin Chinook salmon and steelhead juveniles. Therefore, NMFS will rely on a surrogate take indicator that relates to the proportion of the total abundance of emigrating juvenile salmonids comprised of hatchery-origin Chinook salmon or coho salmon yearlings in the lower Dungeness River for the period after the hatchery fish are released. The surrogate take indicator is a proportion of all hatchery- and naturally-produced juvenile salmon and steelhead emigrating seaward in the Dungeness River downstream of the hatchery release sites on or after the 10^{th} day after the last release of the hatchery-origin Chinook salmon and coho salmon, respectively, that is represented by hatchery-origin Chinook salmon or coho salmon; this proportion should remain smaller than 10 percent.

The proportion of hatchery-origin Chinook salmon or coho salmon yearling versus total juvenile fish abundance will be calculated by statistical week, commencing the fourth week post-hatchery release and continuing until no hatchery-origin Chinook salmon and coho salmon yearlings are captured, as identified either through expanded estimates or catch per unit effort (CPUE). This standard has a rational connection to the amount of take expected from ecological effects, since the co-occurrence of hatchery-origin and natural-origin fish is a necessary precondition to predation, and the assumption that the greater ratio of hatchery fish to natural-origin fish, the greater likelihood that predation will occur. This proportion of hatchery fish in the rearing areas will be monitored by standing co-manager juvenile out-migrant screw trap monitoring activities.

Take by effects of water intake structures

The existing Dungeness River Hatchery water intake structures on the Dungeness River mainstem and Canyon Creek may lead to the take of listed Chinook salmon and listed steelhead. Because take by water intake structures occurs in the water and effects of delay or impingement may not be reflected until the fish have left the area of the structure, it is not possible to quantify the level of take associated with operation of the current water intake structures. Therefore, NMFS will rely on a surrogate take indicator in the form of the amount of habitat affected by the intake structures. Currently, the intake structures affect a very small proportion of total fish habitat available to salmon and steelhead in the watershed. The mainstem intakes present risks of entrainment for juvenile fish in no more than a total of 4 square meters of migration and rearing area adjacent to the intakes. Following completion of the planned construction activities described above the area affected by the intake structures would not change, but the compliance with current NMFS criteria would be expected to reduce the adverse nature of take in that area.

The dam associated with the water intake structure on Canyon Creek currently impedes upstream access to approximately 1.6 miles of potential fish habitat, where only some of the area upstream is suitable habitat for salmonid spawning and rearing. When the fish ladder construction is completed, ESA-listed fish could pass above the current impediment, and therefore be exposed to the water intake structure. The risk of entrainment of juvenile fish would also be in no more than a total of 4 square meters of migration area adjacent to the intake, and only a small proportion of the Dungeness populations would be exposed to this effect.

The surrogate indicator of incidental take is rationally connected to the take associated with operation of the water intake structures, because take occurring by blocked access to habitat or by entrainment or impingement will only occur in the areas identified. This take can be reliably measured by continuing to observe effects associated with the water intakes.

2.8.2. Effect of the Take

In the biological opinion, NMFS determined that the level of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to Puget Sound Chinook salmon and Puget Sound steelhead or in the destruction or adverse modification of 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 the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. The Action Agencies (NMFS and the Bureau of Indian Affairs) shall:

1. Ensure that the effects on Dungeness Chinook salmon genetic diversity associated with implementation of the Dungeness River Hatchery Chinook salmon program are minimized.
2. Ensure that spawning ground competition and redd superimposition effects caused by Dungeness River Hatchery pink salmon are minimized.
3. Ensure that hatchery water intake structures are operated in such a way as to be adequately screened and provide unimpeded upstream and downstream migration for listed Chinook salmon and steelhead.
4. Ensure that broodstock collection operations do not adversely impact natural-origin steelhead.
5. Implement the hatchery programs as described in the three salmon HGMPs and monitor their operation.
6. Indicate the performance and effects of the hatchery salmon programs, including compliance with the Terms and Conditions set forth in the opinion, through completion and submittal of annual reports.

2.8.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Action Agencies have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the following terms and conditions are not complied with, the protective coverage of section 7(o)(2) for the proposed action would likely lapse. The Action Agencies (NMFS and the Bureau of Indian Affairs) shall:

1a. Ensure that annual surveys are conducted to determine the migration timing, abundance, distribution, and origin (hatchery- and natural-origin) of Chinook salmon spawning naturally and escaping to hatchery release sites in the Dungeness River watershed. The co-managers shall submit any revisions of protocols described in the proposed HGMPs for annual spawning ground surveys and biological sampling for NMFS concurrence on or before June 1 of each year.

1b. Ensure that demographic, morphometric, mark/tag, and/or genetic data are collected, and analyses are conducted, necessary to indicate the total annual adult contribution, by origin, of Dungeness Chinook salmon to fisheries and escapement.

1c. Ensure that annual reports are submitted by the co-managers to NMFS, including estimates of natural and hatchery escapement levels, contributions to fisheries for natural and hatchery-origin Dungeness Chinook salmon, and estimates of total recruit per spawner levels for the period when the hatchery Chinook salmon program is implemented (see item 6., below).

2a. Ensure that annual surveys are conducted to determine the migration timing, abundance, and distribution of Dungeness River Hatchery pink salmon that spawn naturally relative to naturally spawning Chinook salmon migration timing, abundance, and distribution. The co-managers shall submit any revisions of protocols described in the proposed HGMPs for annual spawning ground surveys for NMFS concurrence on or before June 1 of each year.

2b. Ensure that annual surveys are conducted to determine the location and extent of any superimposition of Chinook salmon redds by hatchery-origin pink salmon and levels of hatchery-origin pink salmon spawning in Chinook salmon natural spawning areas.

2c. Ensure that annual reports are submitted by the co-managers to NMFS describing results of pink salmon spawner surveys described in 2a and 2b (see item 6., below).

3a. Ensure that all intake structures supplying water for the three Dungeness River Hatchery programs comply with the NMFS Anadromous Salmonid Passage Facility Design criteria (NMFS 2011b) by fall 2019 (Dungeness River intakes); fall 2017 (Canyon Creek intake); and summer 2017 (Hurd Creek intake).

3b. Ensure that the co-managers monitor and annually report hatchery facility compliance with NMFS fish passage criteria (see item 6, below).

3c. Ensure that the co-managers survey migration conditions in the bypass reaches between the Dungeness River Hatchery water intake structures on the Dungeness River and Canyon Creek, and notify the NMFS SFD, within 24 hours, of any injuries, mortalities, or blockages or delays in upstream and downstream migration observed in juvenile or adult Chinook salmon and steelhead.

4a. Ensure that the co-managers immediately release unharmed any natural-origin steelhead incidentally encountered in the course of salmon broodstock collection operations at the point of capture. Hatchery-origin steelhead, identifiable by a clipped adipose fin, that are collected during salmon broodstock collection operations shall be removed and not returned to the river to reduce the threat of genetic and ecological effects on the native Dungeness River steelhead population.

4b. Ensure that the co-managers monitor and annually report the number, location, and disposition of any steelhead encountered during salmon broodstock collection operations (see item 6. below).

5. Ensure that the hatchery programs are implemented as described in the HGMPs, including marking and/or tagging of all juvenile salmon released through the programs. NMFS's Sustainable Fisheries Division (SFD) must be notified in advance of any

change in hatchery program operation and implementation that potentially would result in increased take of ESA-listed species.

6. Provide one comprehensive annual report to NMFS SFD on or before April 1st of each year that includes the RM&E actions described in Term and Conditions 1c, 2c, 3b, and 4b. The numbers of hatchery-origin salmon released – by age/stage, release dates, and release location – and tag/mark information, encounters with other species, and other information pertinent to program operation effects on ESA-listed resources shall be included in the annual report. All reports, as well as all other notifications required, shall be submitted electronically to the SFD point of contact for this program:

    Tim Tynan (360) 753-9579, tim.tynan@noaa.gov

    Annual reports may also be submitted in written form to:

    NMFS – Sustainable Fisheries Division
    Anadromous Production and Inland Fisheries Program
    1201 N.E. Lloyd Boulevard, Suite 1100
    Portland, Oregon 97232

2.9. Conservation Recommendations

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

1. The co-managers, in cooperation with the NMFS and other entities, should investigate the relative reproductive success, and relative survival, of hatchery-origin and natural-origin Chinook salmon in the Dungeness River watershed to further scientific understanding of the genetic diversity and fitness effects of artificial propagation of the species, particularly effects resulting from hatchery subyearling Chinook salmon production.

2.10. Re-initiation of Consultation

This concludes formal consultation for the NMFS determination on, and BIA funding of, three salmon hatchery programs in the Dungeness River watershed.

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

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 action that may adversely affect EFH. The MSA defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside 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 descriptions of EFH for Pacific coast salmon (PFMC 2014) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

The proposed action is the implementation of three hatchery salmon programs in the Dungeness River watershed, as described in detail in Section 1.3. The action area of the proposed action includes habitat described as EFH for Chinook salmon, pink salmon, and coho salmon. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the proposed action on EFH for the three salmon species for which EFH has been designated.

Other fish species for which EFH has been designated in the vicinity of the action area, but whose EFH would not be affected by the proposed action, are identified in Appendix Table 1. Regarding EFH Habitats of Particular Concern (HAPC), the action area encompasses Dungeness Bay, which includes sea grass and estuary HAPCs for West Coast Groundfish (NOAA Fisheries 2015). The only activities that would occur in Dungeness Bay are seaward and river-ward migration by juvenile and adult salmon, respectively, produced by the hatchery programs. HAPCs for West Coast Groundfish would not be adversely affected by hatchery salmon migration through Dungeness Bay.

The areas affected by the proposed action include the Dungeness River from RM 0.0 to the upstream extent of anadromous fish access at RM 18.7; the Gray Wolf River from its confluence with the Dungeness River at RM 15.8 to the upstream extent of anadromous fish access at RM 5.1; Hurd Creek from its confluence with the Dungeness River at RM 2.7 to the upstream extent of anadromous fish spawning; and Dungeness Bay (see Figure 1, above).

Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies accessible, currently or historically, to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable manmade barriers, and long-standing, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years) (PFMC 2014). As described by PFMC (2014), within these areas, freshwater EFH for Pacific salmon consists of four major components: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat.

The Dungeness River and its tributaries accessible to anadromous salmon have been designated EFH for Chinook, coho, and pink salmon. Assessment of the potential adverse effects on these salmon species' EFH from the proposed action is based, in part, on these descriptions. The aspects of EFH that might be affected by the proposed action include: effects of hatchery operations on adult and juvenile fish migration corridors in the Dungeness River watershed; ecological interactions and genetic effects in Chinook, coho, and pink salmon spawning areas in the watershed; and ecological effects in rearing areas for the species in the Dungeness River watershed, including its estuary and adjacent nearshore marine areas.

3.2. Adverse Effects on Essential Fish Habitat

As described below, the proposed action would adversely affect EFH. Generally, the proposed action generally does not have substantial effects on the major components of EFH. Salmon spawning and rearing locations and adult holding habitat are not expected to be affected by the operation of the hatchery programs, as no modifications to these areas would occur. Renovation of water intake structures at Dungeness River Hatchery that have impeded migration is proposed to occur by fall 2019 (Dungeness River intakes); fall 2017 (Canyon Creek intake); and summer 2017 (Hurd Creek intake), and their repair is included as a condition in NMFS's incidental take statement (above) regarding the effects of the three salmon hatcheries.

Potential effects on EFH by the proposed action are only likely to occur in areas where Chinook, pink, and coho salmon spawn naturally and in migration areas in the Dungeness River downstream from RM 15.8. The lone Dungeness River mainstem structure that may affect EFH (i.e., juvenile and adult salmon migration corridors) is a seasonally placed and operated Chinook salmon broodstock collection weir located at RM 2.5. The weir operation is proposed as part of the supportive breeding program for the species to augment broodstock collection at the Dungeness River Hatchery off-channel trap. Any effects on EFH associated with weir placement and operation would be minimized through implementation of best management practices, including: use of a removable weir structure that rests on the river bottom and banks with minimal disruption of riverine habitat; placement and operation of the removable weir for three months each year, and only when Chinook salmon are migrating; continuous surveillance of the weir and trap by staff residing on-site to ensure proper operation and to safeguard fish trapped; twice daily sorting of fish from the trap to minimize trap holding times; and implementation of fish capture and handling methods that protect the health of fish retained as broodstock or released back into the river. For these reasons, no substantial adverse effects on salmon EFH are expected as a result of mainstem weir operation.

Implementation of the Dungeness River Hatchery programs has the potential to result in some degree of genetic diversity change in hatchery Chinook, pink, and coho salmon produced through the programs, in the progeny of naturally spawning hatchery fish, and in the natural populations relative to their baseline diversity and productivity status. The PFMC (2014) recognized concerns regarding the "genetic and ecological interactions of hatchery and wild fish … [which have] been identified as risk factors for wild populations." The biological opinion describes in considerable detail the impacts hatchery programs might have on natural populations

(Section 2.4.2). Additional detail on possible genetic effects of salmon hatchery programs can be found in NMFS (2012b) NWFSC (2015), and Ford (2011). In implementing the Dungeness River Hatchery salmon programs, the co-managers will apply best management practice risk reduction measures described as part of the proposed action. These measures, pertaining to broodstock collection, mating, fish rearing, and fish release practices, are expected to adequately reduce the adverse effect that the supportive breeding programs will have on the genetic diversity and fitness of the Dungeness River Chinook, pink, and coho salmon populations. The co-managers will also monitor and report annual run timing, location, age and sex composition, and origin of escaping salmon to gauge changes in population traits that may be associated with the hatchery actions. Genetic samples (DNA) will be collected from natural-origin and hatchery-origin Chinook salmon used for broodstock for processing by the WDFW Molecular Genetics Lab to monitor the genetic diversity status of the population and divergence between the hatchery and natural-origin aggregations. The hatchery programs for Chinook salmon and pink salmon operate to preserve the native Dungeness River populations of the species through supportive breeding. In addition to maintaining the populations through supplementation, salmon produced through the hatchery programs are intended to escape to natural spawning areas to help recover the abundance and spatial structure, and preserve the diversity of, native Dungeness River Chinook and pink salmon. The programs would likely benefit these viability parameters and recovery of the populations by augmenting natural spawning abundances. These benefits would offset risks to Dungeness Chinook and pink salmon diversity and productivity that may result from natural spawning by hatchery-origin fish at high proportions of total abundances.

Naturally spawning adult salmon produced by the proposed hatchery programs may lead to effects on natural-origin salmon EFH through spawning ground competition and redd superimposition. The biological opinion describes general and specific impacts the hatchery programs might have on naturally spawning salmon populations (Section 2.4.2). The intent of the Dungeness River Hatchery Chinook and pink salmon programs is to produce native stock adult fish that will return to the Dungeness River to spawn naturally. As explained in the biological opinion, the watershed is under-seeded with naturally spawning Chinook and fall-run pink salmon, and competition for spawning sites with adult hatchery-origin salmon that are of the same populations, and redd superimposition by hatchery Chinook and pink salmon, are not concerns. Coho salmon adults originating from the Dungeness River Hatchery harvest augmentation program that escape to natural spawning areas do not overlap temporally and spatially with Chinook or pink salmon, so there would be no effects on those species. Hatchery-origin coho salmon that do not return to the hatchery release site may compete with natural-origin coho salmon for spawning areas and superimpose coho salmon redds. Based on CWT recovery data presented in WDFW (2013c), the majority of hatchery coho salmon escaping to the Dungeness River will be harvested in terminal area fisheries or will return to their Dungeness River Hatchery release site. Few hatchery-origin coho salmon are expected to escape to natural spawning areas where the fish could affect natural-origin coho salmon. In addition, like Dungeness River Hatchery-origin Chinook and pink salmon, coho salmon produced by the hatchery program are the same stock as the extant coho salmon population in the watershed. Some intermixing of hatchery-origin coho salmon and natural-origin coho salmon in natural spawning areas is expected to occur, but the aggregations are of the same native Dungeness River origin (the hatchery-origin coho are derived from the native population), and no effects on coho salmon EFH are expected. The co-managers will monitor and report annual run timing, location, age and sex composition, and origin of escaping salmon to gauge changes on EFH for these spawning area risk factors that may result from the hatchery actions.

As described in Section 2.4.2.6, water withdrawal for the hatchery operations can adversely affect salmon by impeding migration, reducing stream flow, or reducing the abundance of other stream-dwelling organisms that could serve as prey for juvenile salmonids. Structures used for water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures. As discussed in the biological opinion, the Dungeness River Hatchery water intake structures in the Dungeness River may adversely affect salmon EFH through migration and screening impacts. The level of EFH effects is unquantified, as the number, life stage, and proportion of the total migrating salmon populations in the Dungeness River watershed affected by the intake structures have not been estimated. Effects associated with the intakes in the Dungeness River are surmised because actual impacts on fish have not been observed, but the structures are not in compliance with the most recent NMFS standards regarding fish passage and screening requirements for instream structures (NMFS 2011b). WDFW identified renovation of the water intake structures as high-priority capital projects in 2013. Funds were appropriated in 2012 to renovate the intakes to meet current NMFS fish passage and screening requirements, with construction scheduled to begin in 2013 (WDFW 2013a). The proposed hatchery programs include designs to minimize effects on migrating fish. Criteria for fish passage and surface water withdrawal are set to avoid impacts on Chinook, pink, and coho salmon spatial structure. Further, water removed at the structures for hatchery fish rearing will not lead to dewatering of river sections to the detriment of salmon migration. Water use for the hatchery operation is non-consumptive, as all water is returned at an amount equivalent to the volume withdrawn at the hatchery location downstream of the point of withdrawal. Water intake screens are either in compliance with NMFS criteria, or are in the process of renovation so screens are in compliance with those criteria. Under the proposed HGMPs, the co-managers will comply with NMFS Anadromous Salmonid Passage Facility Design criteria (NMFS 2011b) for all water intake structures supplying Dungeness River Hatchery by fall 2019 (Dungeness River intakes); fall 2017 (Canyon Creek intake); and summer 2017 (Hurd Creek intake). They will also monitor and report annually hatchery facility compliance with NMFS fish passage criteria, and will survey migration conditions in the bypass reach between the Dungeness River Hatchery water intake structures and water discharge location on the Dungeness River, and report any blockages or delays observed in juvenile or adult salmon upstream and downstream migration.

3.3. Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the proposed action on EFH for Chinook, pink, and coho salmon, NMFS believes that the proposed action, as described in the HGMPs (USFWS 2009), includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS constitute NMFS recommendations to address potential EFH effects. NMFS and the BIA shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, are carried out.

To address the potential effects on EFH of hatchery fish on natural fish in natural spawning and rearing areas, the Pacific Fishery Management Council (2003) provided an overarching recommendation that hatchery programs:

> "[c]omply with current policies for release of hatchery fish to minimize impacts on native fish populations and their ecosystems and to minimize the percentage of nonlocal hatchery fish spawning in streams containing native stocks of salmonids."

The biological opinion explicitly discusses the potential risks of hatchery fish on fish from natural populations and their ecosystems, and describes operation and monitoring appropriate to minimize these risks on Chinook, pink, and coho salmon in the Dungeness River watershed. By ensuring that the proposed action is implemented as described in the HGMPs, and complying with the terms of the ITS, NMFS and the BIA will, therefore, be fulfilling the recommendation by PFMC (2014). NMFS does not have additional EFH conservation recommendations to provide at this time.

3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. 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, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

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

3.5. Supplemental Consultation

The BIA and NMFS must reinitiate EFH consultation if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations [50 CFR 600.920(l)].

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. NMFS has determined, through this ESA section 7 consultation that operation of the three Dungeness River Hatchery programs as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an ITS. The intended users of this opinion are the WDFW and Jamestown S'Klallam Tribe (operators); NMFS (regulatory agency), and BIA (indirect funding entity). The scientific community, resource managers, and stakeholders benefit from the consultation through adult returns of program-origin salmon to the Dungeness River and Puget Sound, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of Puget Sound Chinook salmon and Puget Sound steelhead. This information will improve scientific understanding of hatchery-origin salmon effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adhere 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 Northwest Region ESA quality control and assurance processes.

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Appendix Table 1. Species of fishes with designated EFH occurring in Strait of Juan de Fuca. The non-Groundfish species that have EFH in the analysis area for the Dungeness River hatchery programs are Chinook, pink, and coho salmon.

Groundfish Species	redstripe rockfish *S. proriger*	Dover sole *Microstomus pacificus*
spiny dogfish *Squalus acanthias*	rosethorn rockfish *S. helvomaculatus*	English sole *Parophrys vetulus*
big skate *Raja binoculata*	rosy rockfish *S. rosaceus*	flathead sole *Hippoglossoides elassodon*
California skate *Raja inornata*	rougheye rockfish *S. aleutianus*	petrale sole *Eopsetta jordani*
longnose skate *Raja rhina*	sharpchin rockfish *S. zacentrus*	rex sole *Glyptocephalus zachirus*
ratfish *Hydrolagus colliei*	splitnose rockfish *S. diploproa*	rock sole *Lepidopsetta bilineata*
Pacific cod *Gadus macrocephalus*	striptail rockfish *S. saxicola*	sand sole *Psettichthys melanostictus*
Pacific whiting (hake) *Merluccius productus*	tiger rockfish *S. nigrocinctus*	starry flounder *Platichthys stellatus*
black rockfish *Sebastes melanops*	vermilion rockfish *S. miniatus*	arrowtooth flounder *Atheresthes stomias*
bocaccio *S. paucispinis*	yelloweye rockfish *S. ruberrimus*	
brown rockfish *S. auriculatus*	yellowtail rockfish *S. flavidus*	**Coastal Pelagic Species**
canary rockfish *S. pinniger*	shortspine thornyhead *Sebastolobus alascanus*	anchovy *Engraulis mordax*
China rockfish *S. nebulosus*	cabezon *Scorpaenichthys marmoratus*	Pacific sardine *Sardinops sagax*
copper rockfish *S. caurinus*	lingcod *Ophiodon elongatus*	Pacific mackerel *Scomber japonicus*
darkblotch rockfish *S. crameri*	kelp greenling *Hexagrammos decagrammus*	market squid *Loligo opalescens*
greenstriped rockfish *S. elongatus*	sablefish *Anoplopoma fimbria*	**Pacific Salmon Species**
Pacific ocean perch *S. alutus*	Pacific sanddab *Citharichthys sordidus*	Chinook salmon *Oncorhynchus tshawytscha*
quillback rockfish *S. maliger*	butter sole *Isopsetta isolepis* curlfin sole *Pleuronichthys decurrens*	coho salmon *O. kisutch*
redbanded rockfish *S. babcocki*		Puget Sound pink salmon *O. gorbuscha*