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 Ten Hatchery and Genetic Management Plans for Salmon and Steelhead in Hood Canal under Limit 6 of the Endangered Species Act Section 4(d) Rule

NMFS Consultation Number: WCR-2014-1688

Action Agencies: National Marine Fisheries Service
United States Fish and Wildlife Service
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
Hood Canal Summer Chum salmon (*O. keta*)	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: Stephen P. Freese
for Barry A. Thom
Regional Administrator

Date: 9/30/2016

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1. INTRODUCTION

The Washington Department of Fisheries and Wildlife (WDFW) and the Port Gamble S'Klallam and Skokomish Tribes (co-managers), along with the United States Fish and Wildlife Service (USFWS) propose to operate several hatchery programs that release Chinook, coho, pink and fall chum salmon and steelhead into Hood Canal, Washington (Table 1). The integrated[1] Hamma Hamma Chinook salmon and Hood Canal Steelhead Supplementation programs provide conservation benefits for species listed under the Endangered Species Act (ESA). The remaining eight programs are isolated[1] implemented to help meet tribal fishery harvest allocations guaranteed through treaties, as affirmed in *United States* v. *Washington* (1974) and through Pacific Salmon Treaty harvest sharing agreements with Canada.

Table 1. Hatchery programs proposed for operation in Hood Canal.

Hatchery Program	Operator	Funder	Program Purpose	Date Submitted
Hamma Hamma Fall Chinook Supplementation	LLTK/HCSEG/ WDFW	USFWS/LLTK	Integrated Recovery	May 1, 2013
Hood Canal Steelhead Supplementation	WDFW/LLTK/NMFS	WDFW/LLTK/NMFS	Integrated Recovery	November 28, 2012
Quilcene National Fish Hatchery Yearling Coho Salmon	USFWS	USFWS	Isolated Harvest	July 15, 2013
Hoodsport Hatchery Fall Chinook	WDFW	WDFW/DJ/PSRFE	Isolated Harvest	July 23, 2013
Hoodsport Hatchery Fall Chum	WDFW	WDFW/DJ/PSRFE	Isolated Harvest	January 11, 2013
Hoodsport Hatchery Pink Salmon	WDFW	WDFW/DJ/PSRFE	Isolated Harvest	July 15, 2013
Port Gamble Coho Net Pen	PGST	BIA	Isolated Harvest	February 28, 2013
Port Gamble Hatchery Fall Chum	PGST	BIA	Isolated Harvest	February 28, 2013
Quilcene Bay Coho Net Pen	ST	BIA	Isolated Harvest	September 18, 2013
Skokomish Enetai Creek Hatchery Fall Chum	ST	BIA	Isolated Harvest	September 10, 2013

LLTK = Long Live the Kings; HCSEG = Hood Canal Salmon Enhancement Group; PGST = Port Gamble S'Klallam Tribe; ST = Skokomish Tribe; BIA = Bureau of Indian Affairs; DJ = Dingell-Johnson Sportfishing Restoration Act; PSREF = Puget Sound Recreational Enhancement Fund.

1.1. Background

NMFS prepared the biological opinion (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

[1] Integrated: Program designed to reduce the risk of genetic divergence between hatchery and natural fish by promoting natural selection. Isolated (referred to in the co-manager plans as segregated): Program that has a level of genetic divergence, relative to the natural population, that is more than what occurs with the ESU or DPS and promotes selection of hatchery traits.

seq.), and implementing regulations (50 CFR 402). The Opinion documents the consultation on the actions proposed by NMFS, the USFWS and the Bureau of Indian Affairs (BIA) and is based on information provided in the 10 HGMPs.

NMFS also completed an Essential Fish Habitat (EFH) consultation prepared 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 (50 CFR 600). The opinion, incidental take statement, and EFH conservation recommendations are in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act") and underwent pre-dissemination review.

An associated Environmental Assessment for the Hood Canal Hatchery programs was also prepared to meet NEPA requirements. The project files for both consultations are held at the NMFS Sustainable Fisheries Division in Portland, Oregon.

1.2. **Consultation History**

The first hatchery consultations in Puget Sound followed the ESA listing of the Puget Sound Chinook Evolutionarily Significant Unit (ESU, 64 FR 14308, NMFS & NOAA 1999b) and Hood Canal summer chum ESU (64 FR 14508, NMFS & NOAA 1999a). In 2005, WDFW and the Puget Sound treaty tribes completed two resource management plans (PSTT and WDFW 2004) as the overarching framework for 114 Hatchery and Genetic Management Plans (HGMPs). The HGMPs described how each hatchery program would operate, including effects on listed fish in the Puget Sound region. The co-managers submitted the plans to NMFS for ESA review under limit 6 of the 4(d) rule (50 CFR 223.203). Subsequent to the submittal of the plans to NMFS, the Puget Sound steelhead Distinct Population Segment (DPS) was listed as "threatened" (72 FR 26722, NMFS & NOAA 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, NMFS & NOAA 2008), the same 4(d) protections already adopted for other ESA-listed Pacific salmon and steelhead in the region (70 FR 37160, NMFS 2005a).

The effects of take associated with implementation of the Hood Canal programs on the Hood Canal Summer Chum Salmon ESU were previously evaluated and authorized by NMFS through a separate ESA section 7 consultation process (NMFS 2002). An Environmental Assessment and finding of no significant impact (FONSI) were completed as part of the previous NMFS summer chum salmon consultation (NMFS 2002). Effects on this listed species associated with the proposed salmon HGMPs are incorporated into the Environmental Baseline, and are not discussed further in this biological opinion, except as they relate to the Hood Canal Steelhead Supplementation Program, which began operation after the NMFS 2002 consultation was completed.

The applicants requested processing of the 10 Hood Canal HGMPs under limit 6 of the 4(d) rule. After review, NMFS determined the plans included information sufficient[2] for the agency to

[2] "Sufficient" means that an HGMP meets the criteria listed at 50 CFR 223.203(b)(5)(i): (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

determine whether the HGMPs addressed criteria specified in Limit 6 of the 4(d) rule for the Puget Sound Chinook Salmon ESU, Hood Canal Summer Chum Salmon ESU and the Puget Sound Steelhead DPS. NMFS's review will lead to a determination of whether the plans address 4(d) rule limit 6 criteria for the Puget Sound Chinook Salmon ESU, the Hood Canal Summer Chum Salmon ESU and the Puget Sound Steelhead DPS. 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.

1.3. **Proposed Actions**

"Action" means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies. Interrelated actions are part of a larger action and depend on the larger action for their justification. Interdependent actions have no independent utility apart from the action under consideration. NMFS has identified the Puget Sound Chinook salmon fishery as interrelated with this action (section 2.4.2.7). Factor 7. Fisheries that exist because of the hatchery program

The Proposed Actions are:

- NMFS determination that 10 Hood Canal hatchery programs address the criteria under limit 6 of the ESA 4(d) rule for their effects on listed Puget Sound salmon and steelhead (50 CFR 223.203(b)(6));
- Funding by NMFS to support the Hood Canal Steelhead Supplementation Program
- Funding and operation of the Quilcene National Fish Hatchery by the USFWS
- Funding by the Bureau of Indian Affairs (BIA) for the Port Gamble S'Klallam and Skokomish Tribes' operation of the Hood Canal programs, in support of their treaty rights (Table 1).

Activities included in the HGMPs for analysis are:

- Broodstock collection and spawning
- Egg incubation and juvenile rearing
- Juvenile release
- Research, monitoring and evaluation to assess program performance

Table 6 describes ESA-listed salmon and trout species under NMFS jurisdiction considered in this opinion. In addition, NMFS has determined that the proposed action would have no effect on ESA-listed Pacific eulachon, southern resident killer whales, or rockfish. This determination is based on the likely absence of adverse effects on any of these species, and the very small proportion of the total numbers of fish present in the areas these species occupy that would overlap with Hood Canal hatchery-origin salmon. Therefore, we will not address these species further in this opinion.

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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.

1.3.1. **Broodstock Collection and Spawning**

Broodstock are the adult salmon or steelhead that are collected as the parent stock for the next, successive, generation of hatchery juveniles for program release. Broodstock are taken as a representative sample throughout total adult returns. No adults are collected surplus to broodstock needs for the Hamma Hamma Chinook Salmon Supplementation Program. This is the only program collecting broodstock for listed Chinook salmon; Hoodsport Hatchery Chinook salmon are not included in the Puget Sound Chinook salmon ESU. The Hood Canal Steelhead Supplementation Program uses steelhead eyed-eggs collected from natural-origin redds as broodstock (Table 2). Hatchery personnel will pass any listed species encountered during broodstock collection for the segregated programs upstream to continue their spawning migration.

Quilcene National Fish Hatchery operates a weir that spans the entire Big Quilcene River for broodstock collection (Table 2). Hatchery personnel open the sliding gates periodically from September through December on the fish bypass ladder to allow some coho salmon and all steelhead to pass upstream. From January 1 through July, the gates for the ladder are opened continuously to allow upstream passage of any steelhead (USFWS 2015). In addition, during this time, river flows may be high enough to allow passage of fish over the weir (Correa 2002).

The Hoodsport Hatchery weir is removable and hatchery staff place the weir in Finch Creek from July 1 through December to collect broodstock for the three hatchery programs implemented at the facility. Located at the creek mouth, the weir then directs returning hatchery-origin adults into a holding pond for retention through maturation and spawning (WDFW 2013a; WDFW 2013b; WDFW 2014). Both of the chum salmon programs at Port Gamble and Enetai Creek Hatcheries use permanent weirs at the mouths of Little Boston and Enetai Creeks, respectively, to collect adults and direct them into a holding pond for hatchery use (Port Gamble S'Klallam Tribe 2013b; Skokomish Tribe 2013b).

Table 2. Broodstock collection and spawning details.

Program	Collection Location	Collection Method	Collection Duration	# Adults Collected	Sex Ratio (Female:Male)	Spawning Approach
Hamma Hamma Fall Chinook	Hamma Hamma River	Block seine or Hook and Line	September 10 to October 21	60	1:1	Factorial
Hood Canal Steelhead	Dewatto, Duckabush, Skokomish Rivers	Hydraulic pump (eggs)	NA	62,802 (eggs)	NA	NA
Hoodsport Fall Chinook	Finch Creek	Removable weir	July to mid-December	2500	1:1	Pairwise
Hoodsport Fall Chum	Finch Creek	Removable weir	July to mid-December	9000	3:2	Factorial
Hoodsport Fall Pink	Finch Creek	Removable weir	July to mid-December	920	1:1	Pairwise
Port Gamble Fall Chum	Little Boston Creek	Weir	October to November	1300	2:1	Factorial

Skokomish Fall Chum	Enetai Creek	Weir	November	3000	1:1	Factorial
Port Gamble Coho Net Pens	NA	NA	NA	NA	NA	NA
Quilcene Coho Net Pens	NA	NA	NA	NA	NA	NA
Quilcene National Fish Hatchery Coho	Big Quilcene River	Weir	August to December	1500	1:1	Pairwise

All available broodstock are spawned randomly, without consideration for age or size. Factorial mating is preferred because it preserves genetic diversity and reduces the impact of sterile adults. For example, in a 2 x 2 factorial cross, eggs from two females are pooled and then split into four separate containers. Milt from each of two males is then added to two of the four containers.

1.3.2. **Egg Incubation and Juvenile Rearing**

Rearing of ESA-listed fish only occurs for the Hamma Hamma Chinook salmon and the Hood Canal steelhead supplementation programs. Thus, concerns for listed fish within the hatchery during egg incubation and rearing are restricted to these two programs.

Eggs for the Hamma Hamma Chinook salmon program are shipped to George Adams hatchery for fertilization, eying and incubation. Eggs are eyed in troughs supplied with well water and then moved to vertical incubators. When 95 percent of the fish have yolks that are absorbed, fish are moved to raceways supplied with water from Purdy Creek and loaded at densities in accordance with Piper et al. (1986). Once fish reach a size of 75 to 85 fish per pound (fpp), hatchery personnel transfer the fish to either earthen ponds or fiberglass raceways at the Johns Creek Conservation Site until they reach an average size of 60 to 75 fpp for release.

After collection from the Dewatto, Duckabush, and Skokomish Rivers, eggs for the Hood Canal steelhead supplementation program are transferred to the isolation buildings supplied with pathogen-free well water at either McKernan (Skokomish origin) or Quilcene National Fish Hatchery (Dewatto and Duckabush). At approximately 600 C degree days, fry from Quilcene National Fish Hatchery will be ponded and transferred to Lilliwaup Hatchery, where they will remain until they reach an average release size of 8 fpp (smolts) or 8 pounds (adults). Reporting and control of specific fish pathogens during hatchery rearing will be conducted in accordance with the co-managers of Washington and USFWS fish health policies (NWIFC and WDFW 2006; USFWS 2004).

Table 3. Survivial of ESA-listed fish during incubation and rearing.

Program	Eggs Collected	Life Stage Released	Average Egg-Release Survival (%)
Hamma Hamma Fall Chinook Supplementation	104,500	subyearling	85.7
Hood Canal Steelhead Supplementation Project	62,802	yearling	81.0
		adult	81.0

1.3.3. **Program Release**

Fish release details for each program are summarized in Table 4.

Table 4. Summary of hatchery salmon and steelhead releases proposed for Hood Canal region programs.

Program	Release #	Life Stage	Mark	Volitional Release?	Acclimation	Release Site	Release Date
Hamma Hamma Fall Chinook Supplementation	95,000	subyearling	100% CWT	Yes	Hamma Hamma River	John Creek	mid-May to mid-June
Hood Canal Steelhead Supplementation Project	7,400	yearling	100% ad clip	No	Hamma Hamma or Big Quilcene River	Dewatto River	April 15-May 15
	6,667	yearling	100% ad clip			Duckabush River	April 15-May 16
	34,500	yearling	100% ad clip			Skokomish River	April 15-May 17
	253, alternate years	adult	100% floy			Dewatto River	Feb-March
	230, alternate years	adult	100% floy			Duckabush River	Feb-May
	400	adult	100% floy			Skokomish River	March-May
Hoodsport Hatchery Fall Chinook	3 million 120,000	subyearling yearling	100% ad clip; ~10% ad clip+ CWT	No	Hood Canal Saltwater	Finch Creek/HC confluence	late May-June late April-May
Hoodsport Hatchery Fall Chum	12 million	fry	None	No	Hood Canal Saltwater	Finch Creek/HC confluence	April
Hoodsport Hatchery Pink	500,000	fry	None	No	Hood Canal Saltwater	Finch Creek/HC confluence	April
Port Gamble Coho Net Pens	400,000	yearling	78% ad clip; 11% CWT; 11% ad clip+ CWT	No	Hood Canal Saltwater	Port Gamble Bay	May
Port Gamble Hatchery Fall Chum	950,000	fry	None	Yes	Little Boston Creek	Little Boston Creek	April-May

Quilcene National Fish Hatchery Yearling Coho Salmon Production	400,000	yearling	78% ad clip; 11% CWT; 11% ad clip+ CWT	Yes	Big Quilcene River	Big Quilcene River	late April-early May
Skokomish Enetai Creek Hatchery Fall Chum	3.2 million	fry	None	No	Enetai Creek	Enetai Creek	April
Quilcene Bay Coho Net Pens	200,000	yearling	55% ad clip; 22.5% CWT; 22.5% ad clip+ CWT	No	Hood Canal Saltwater	Quilcene Bay	May

1.3.4. **Adult Management**

Adults originating from the Hamma Hamma Chinook salmon and the Hood Canal steelhead supplementation programs both intend for hatchery-origin fish to spawn naturally to increase fish abundance. Thus, there are no pHOS or straying standards proposed for these two programs. The only intended removal of adults originating from either of these programs is for Chinook salmon returning to the Hamma Hamma River for broodstock. Spawned broodstock carcasses for the Hamma Hamma Chinook salmon supplementation program are returned to the river for nutrient enhancement.

From the eight segregated programs, hatchery personnel either sell carcasses to a contracted fish buyer or give them to food banks or tribal members for subsistence. Fish treated for pathogens or otherwise unfit for human consumption are taken to a rendering plant. Surplus adults returning to the hatchery are disposed of in the same manner, except for Quilcene National Fish Hatchery, which passes ~200-800 adult coho upstream for natural spawning and nutrient enhancement.

1.3.5. **Research, Monitoring, and Evaluation**

All programs implement standard monitoring and evaluation practices to determine fish health, egg and juvenile fish survival, and other hatchery-related performance metrics. In addition, the applicants propose to estimate the annual number of marked and unmarked adult fish escaping to the hatcheries and natural spawning areas in the region to monitor straying and the contribution of each program to fisheries, escapement, and recovery goals. However, because all hatchery-origin fall chum and pink salmon fry are released without marks, it is not possible to collect this data for these species.

The Hood Canal steelhead supplementation program proposes additional research to improve our understanding of steelhead life history, genetics and movement:

- Redd counts to estimate spawner abundance
- Outmigrant juvenile collection to estimate production
- Use of telemetry tagged outmigrants to estimate ocean survival and migration
- Sampling of natural- and hatchery-reared adults and juveniles for genetic analysis of heterozygosity, loss of rare alleles or change in allele frequencies
- Sampling of natural- and hatchery-reared adults and juveniles for determining contribution of resident populations to smolts with an anadromous life history

The Quilcene National Fish Hatchery Yearling Coho Program also proposes additional research to investigate the extent of hatchery operations on the surrounding ecosystem. The research objectives in the USFWS Pacific Region Hatchery Review Initiative (USFWS 2005) include sampling of non-listed fish for:

- pathogens
- diet
- aging
- marine-derived nutrient proportions

The Quilcene coho program may affect non-listed populations through the transfer of pathogens, contribution to diet and distributing marine-derived nutrients. Although no sampling of listed fish is proposed, researchers may encounter listed fish during surveying and sampling of non-listed species.

1.3.6. Operation, Maintenance, and Construction of Hatchery Facilities

All of the freshwater hatchery facilities have current surface water right permits issued by Washington Department of Ecology (Ecology) authorizing water withdrawals up to the maximum permitted amounts (Table 5). In addition, all hatchery facilities are compliant with or do not require a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits are not required for hatchery facilities that release less than 20,000 pounds of fish per year or use less than 5,000 pounds of fish feed per month (Table 5). Monitoring and measurement of water usage and quality are reported monthly to Ecology. All water intakes are also in compliance with NMFS screening criteria guidelines (NMFS 2011a), except for Hoodsport, Port Gamble and Eentai Creek hatcheries because listed fish are not present (Port Gamble S'Klallam Tribe 2013b; Skokomish Tribe 2013b; WDFW 2013a; WDFW 2013b; WDFW 2014).

Table 5. Facility operation details.

Facility	Surface Water (cfs)	Ground-water (cfs)	Surface Water Source	Compliant with NPDES permit?	Compliant with NMFS screening criteria?
Quilcene National Fish Hatchery	65.2	0.8	Big Quilcene River; Penny Creek	Yes	Yes
Port Gamble net pens	NM[1]	NA[1]	Port Gamble Bay	NA	NA
Quilcene net pens	NM	NA	Quilcene Bay	NA	NA
Hoodsport Hatchery	18.9 fresh 3.6 salt	0.7	Finch Creek and Puget Sound	Yes	No
Enetai Hatchery	2.7	NA	Enetai Creek	NA	No
Port Gamble Hatchery	1	NA	Little Boston Creek	NA	No
John Creek Conservancy Site	1	NA	John Creek	NA	No
McKernan Hatchery	12.0	6.4	Weaver Creek	Yes	Yes
George Adams Hatchery	23.8	6.4	Purdy Creek and Ellis Spring	Yes	No
Lilliwaup Hatchery	2.2	NA	Beardsley and unnamed Creek	NA	No
Manchester Research Station	0.6	0.1	Puget Sound	NA	NA

[1]NA = not applicable; NM = not measurable

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. In determining whether there are interrelated and interdependent actions that should be considered in this consultation, NMFS has considered whether fisheries impacting Hood Canal hatchery fish are interrelated or interdependent actions that are subject to analysis in this opinion.

Within the Hood Canal action area, recreational and tribal commercial, and tribal ceremonial and subsistence, fisheries occur, targeting unlisted Chinook, pink, coho, and fall chum salmon produced by the proposed hatchery programs. These fisheries are managed by the Point No Point Treaty tribes and WDFW, and occur within Hood Canal marine waters and, in some years, the Big Quilcene River. The proposed hatchery programs analyzed in this opinion also contribute to regional fisheries outside of Hood Canal. 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.

Fisheries are not included in this proposed action. The effects of all fisheries that incidentally harvest ESA-listed fish species originating from the Hood Canal region, including fisheries within the action area directed at surplus hatchery-origin salmon, have been evaluated through a separate NMFS ESA consultation (NMFS 2015). Through that consultation, NMFS' concluded that proposed Puget Sound region harvest actions are not likely to jeopardize the continued existence of the Puget Sound Chinook Salmon ESU, Hood Canal Summer Chum Salmon ESU or the Puget Sound Steelhead DPS or adversely modify proposed designated critical habitat (NMFS 2015b). For these reasons, effects of fisheries inside and outside of the Hood Canal action area are not analyzed again in this opinion, though the effects of fisheries are included in the Environmental Baseline.

Research conducted to assess juvenile outmigration timing and life history characteristics is conducted throughout various watersheds in Hood Canal using screw traps and electrofishing equipment. These activities have previously been covered under ESA section 10 permits for Long Live the Kings on the Hamma Hama River (# 19013) and for WDFW on the Duckabush River (# 19769) and Little Anderson, Stavis, Seabeck, and Big Beef Creeks (# 19940 and 19965). More information on these permits can be found on the APPS database (https://apps.nmfs.noaa.gov). Biological opinions on the issuance of these permits found that the actions would not jeopardize the continued existence of ESA-listed species, or destroy or adversely modify designated critical habitat.

1.5. **Action Area**

The “Action Area” means all areas to be affected directly or indirectly by the Proposed Action, in which the effects of the action can be meaningfully detected measured, and evaluated (50 CFR 402.02). The Action Area resulting from this analysis includes the all of the freshwater tributaries and marine waters of the Hood Canal region. This includes areas where salmon and steelhead are collected as broodstock, spawned, incubated, reared, acclimated, and released (Figure 1).

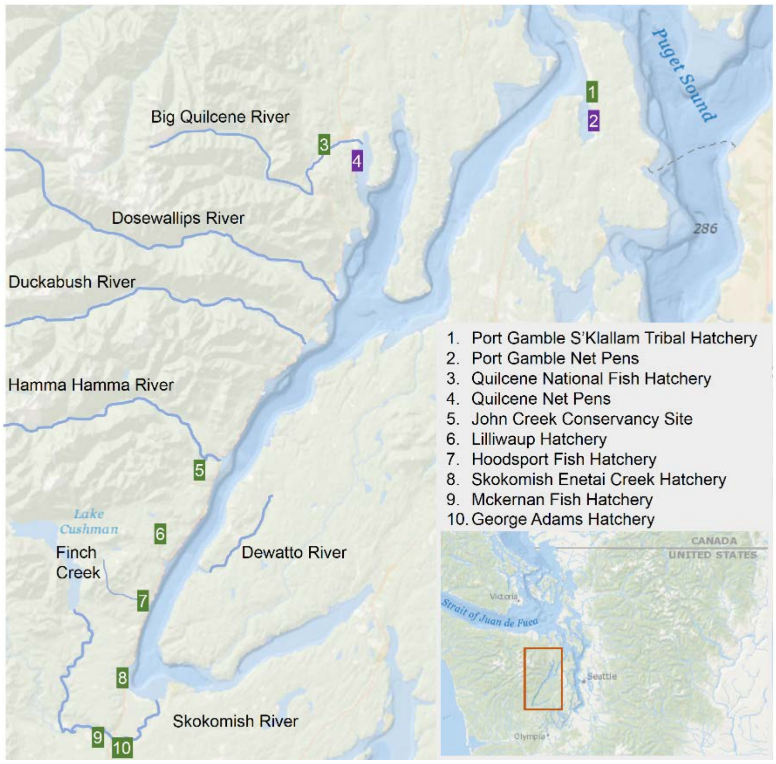

Figure 1. Location of hatchery programs and major Hood Canal tributaries included in this analysis.

NMFS considered whether the marine areas of Puget Sound outside of Hood Canal and the ocean should be included in the Action Area. The potential concern is a relationship between hatchery production and density-dependent interactions affecting salmon growth and survival. However, NMFS has determined that, based on best available science, it is not possible to establish a connection between hatchery production on the scale anticipated in the Proposed Action and the marine areas outside of Hood Canal. In addition, the 10 programs considered in this Opinion contribute less than 15 percent of the 146 million salmon and steelhead hatchery fish produced in Puget Sound (NMFS 2014a). Therefore, it is unlikely that there would be detectible effects in the marine environment beyond Hood Canal, which could be attributable to the proposed action.

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 incidental take statement (ITS) that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

2.1. **Introduction to the Biological Opinion**

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. The adverse modification analysis considers the impacts on the conservation value of the designated critical habitat.

"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).

The adverse modification analysis considers the impacts of the Federal action on the Biological Opinion, EFH Consultation, and FWCA Guidance regarding conservation value of designated critical habitat. 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 7414, February 11, 2016).

The designations of critical habitat for Chinook and chum salmon considered in this opinion use the term "primary constituent elements" (PCE), while the steelhead designation uses the term "physical and biological 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 primary constituent elements, physical or biological features, or essential features. In this biological opinion, we use the terms "PCE" and "PBF", as appropriate for the specific 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 physical and biological features. 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 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 that are contemporaneous with the consultation in process (50 CFR 402.02).The Environmental Baseline is discussed in section 2.3 of this opinion.

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.

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, and these are combined with the overall status of the strata/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 Reasonable and Prudent Alternative(s) to the proposed action.

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

This opinion examines the status of each species and designated critical habitat that would be affected by the Proposed Action (Table 6). 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.

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

Table 6. Federal Register (FR) notices 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
Summer chum salmon (*O. keta*)			
Hood Canal	Threatened, March 24, 1999; 64 FR 14508	February 16, 2000; 65 FR 7764	June 28, 2005; 70 FR 37160
Steelhead (*O. mykiss*)			
Puget Sound	Threatened, May 11, 2007; 72 FR 26722	February 24, 2016, 2013; 81 FR 9252	September 25, 2008; 73 FR 55451

2.2.1. Status of Listed Species

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

"Abundance" generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds).

"Productivity," as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults produced per their naturally spawning parental pair. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany et al. (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 habitat quality and spatial configuration and the dynamics and dispersal characteristics of individuals in the population.

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

For species with multiple populations, once the biological status of a species' populations has been determined, NMFS assesses the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread, to avoid concurrent extinctions from mass catastrophes, and spatially close, to allow functioning as metapopulations (McElhany et al. 2000).

2.2.1.1. Life History and Status of Puget Sound Chinook salmon

Chinook salmon exhibit a variety of life history patterns that include variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: “stream-type” and “ocean-type” (Healey 1991; Myers et al. 1998). Ocean-type Chinook salmon reside in coastal ocean waters for 3 to 4 years and enter freshwater for spawning later (June through August) than stream-type Chinook salmon (March through July; Myers et al. 1998). Ocean-type Chinook salmon also spawn and rear in lower elevation mainstem rivers and they typically reside in freshwater for no more than 3 months compared to stream-type Chinook salmon that spawn and rear high in the watershed and reside in freshwater for a year.

The Puget Sound Chinook Salmon ESU encompasses all runs of Chinook salmon from rivers and streams flowing into Puget Sound, including the Straits of Juan de Fuca from the Elwha River eastward, Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington. The Puget Sound Technical Recovery Team (PSTRT) determined there are currently 22 extant historical populations (grouped into five biogeographic regions) and 16 additional spawning populations that are now putatively extinct (Ruckelshaus et al. 2006). Twenty-six artificial Chinook salmon propagation programs are included within the ESU, including the George Adams and Hamma Hamma programs within Hood Canal (70 FR 37160, NMFS 2005a). 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 salmon, which describes the population structure, identifies populations essential to ESU recovery and establishes recovery goals (NMFS 2006a; SSPS 2005). The recovery goals consider the population level viability criteria recommended by the PSTRT (Ruckelshaus et al. 2002) and will be met when:

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

The Action Area is encompassed within the Hood Canal biogeographic region. This region comprises two populations: Skokomish River and mid-Hood Canal. The mid-Hood Canal population is an aggregate of Chinook salmon from the Dosewallips, Duckabush and Hamma Hamma Rivers. For recovery of the ESU to occur, both populations within the Hood Canal region would need to attain a low long-term risk status by meeting abundance and productivity targets (Table 7). Indices of spatial distribution and diversity have not been developed at the population level (Ford 2011). However, the diversity of Chinook in mid-Hood Canal has been reduced compared to historical diversity through the loss of the early-returning life histories and the extensive use of Green River lineage hatchery Chinook salmon throughout the region (SSPS 2005).

Limiting factors for the recovery of Chinook salmon in Hood Canal include: past logging practices leading to habitat loss and degradation; past fishing regimes leading to decreased abundance; and outplanting of hatchery juveniles in mid-Hood Canal until 1991 (SSPS 2005).

Table 7. Abundance and productivity estimates for the Hood Canal region.

Population	Geometric mean natural-(total) Spawner Escapement (2010-2014)[1]	Productivity (2002-2006)[2]	NMFS Escapement Thresholds[3]		Spawner Abundance Target (productivity)[4]
			Critical	Rebuilding	
Skokomish River	256 (1627)	0.93	200	1,250	unknown
Mid-Hood Canal	75 (314)	2.0	200	1,250	1,300 (3.0); 5,200 (1.0)

[1] Source (NWFSC 2015); includes naturally spawning hatchery fish; SD = standard deviation
[2] Source (Ford 2011); measured as recruits/spawner
[3] Source (McElhany et al. 2000; NMFS 2004c); under current habitat and environmental conditions
[4] Source (NMFS 2006a); measured as recruits/spawner under recovered conditions with high and low productivity

2.2.1.2. Life History and Status of Puget Sound Steelhead

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

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

Because our Action Area for this proposed action is Hood Canal, we will focus on the status of the Hood Canal DIPs within the Hood Canal/Strait of Juan de Fuca MPG. This MPG contains eight DIPs, including two summer/winter and six winter DIPs, which account for 12 percent of the steelhead abundance in the DPS (Hard et al. 2015). The four winter Hood Canal DIPs comprise the majority of steelhead in the MPG. Steelhead abundance in all four DIPs is below the intrinsic potential based on current conditions (Table 8). There is some uncertainty about the presence of summer-run life histories, but, if present, they are likely small in number (Myers et al. 2015). In addition, further research on the rate of straying and life history characteristics of steelhead populations in Hood Canal may alter these tentative classifications and criteria.

Table 8. Hood Canal DIPs within the Hood Canal and Strait of Juan de Fuca MPG.

Population	Primary Tributaries	Geometric Mean Total Natural Spawners (Numbers of Fish, 2010-2014)[1]	Growth Rate (1995-present)[2]	Intrinsic Potential[2] (Numbers of Fish)	Extinction Risk[2]
South Hood Canal	Tahuya and Union Rivers	64 (64)	0.90	2,985-5,970	High 0.9
West Hood Canal	Quilcene, Hamma Hamma, Duckabush, Dosewallips Rivers	(74)	1.06	3,608-7,216	Low < 0.2
East Hood Canal	Big Beef and Anderson Creeks, Dewatto River	60 (60)	0.99	1,270-2,540	Low 0.4
Skokomish River	Skokomish River	(580)	1.01	10,030-20,060	High 0.7

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

2.2.1.3. Life History and Status of Hood Canal Summer Chum Salmon

Summer chum enter the estuary during the late winter/early spring as seaward-migrating juveniles. When they mature at sea, primarily at 3 and 4 years of age, summer chum enter the Hood Canal terminal area from early August through the end of September (WDF et al. 1994). Spawning ground entry timing in Hood Canal ranges from late August through mid-October with spawning occurring from late August through late October, generally within the lowest one to two miles of the tributaries (NMFS 2002).

The ESU has two geographically distinct regions with one independent population each: the Strait of Juan de Fuca and Hood Canal (Sands et al. 2009). Although the populations share similar life history traits, the two regions are affected by different environmental and harvest impacts, and display varying survival patterns and stock status trends (WDFW and PNPTT 2000).

Achievement of species recovery is dependent on addressing the primary factors that led to the listing decision: climate-related changes in stream flow patterns, fishery exploitation, and habitat loss (HCCC 2005). The recovery plan details the actions and associated monitoring needed to ensure these factors are no longer limiting recovery as well as recovery goals and criteria. Long-term recovery criteria developed by the PSTRT for the Hood Canal Summer Chum ESU are:

1. A viable natural spawning population in the Strait of Juan de Fuca and the Hood Canal would have an abundance of 4,500 or 12,500 and 18,300 or 24,700 respectively, with the high number corresponding to a lower productivity
2. Spawning aggregations are distributed across the historical range of the population
3. Most spawning aggregations are within 20 km of adjacent aggregations
4. Major spawning aggregations are distributed across the historical range of the population and are not more than 40 km apart
5. A viable population includes one or more persistent spawning aggregations from each of the two to four major ecological diversity groups historically present

Because our Action Area is restricted to Hood Canal, we only describe the status of the Hood Canal population. The geometric mean in total spawner abundance of summer chum in Hood Canal has increased compared to what it was at the time of listing: 15,553 (2010-2014) versus 7,223 (1995-1999; NWFSC 2015), but is still below the minimum viable population abundance goal of 24,700. The Hood Canal summer chum salmon population also has a recruit/spawner ratio of 2.02 (2002-2006), which exceeds the replacement rate of one and suggests a continued increase in abundance. Assessment of productivity has been variable, but is currently higher (1.98, 2005-2009) than at the time of listing (1.06, 1995-1999; Ford 2011).

2.2.2. **Status of Critical Habitat**

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

1. Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation and larval development
2. Freshwater rearing sites with:

(i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility

(ii) Water quality and forage supporting juvenile development

(iii) Natural cover

3. Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover supporting juvenile and adult mobility and survival

4. Estuarine areas free of obstruction and excessive predation with:

(i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater

(ii) Natural cover

(iii) Juvenile and adult forage supporting growth and maturation.

5. Nearshore marine areas free of obstruction and excessive predation with:

(i) Water quality and quantity conditions and forage supporting growth and maturation

(ii) Natural cover

6. Offshore marine areas with water-quality conditions and forage supporting growth and maturation.

2.2.2.1. Status of Critical Habitat for Puget Sound Chinook Salmon

Designated critical habitat for the Puget Sound Chinook Salmon ESU includes estuarine areas and 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, NMFS 2005b). 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 populations because of their importance to rearing and migration for Chinook salmon and their prey.

Conservation value ratings for Hood Canal were high for the Skokomish, Duckabush, and Dosewallips Rivers due to their importance for the two independent populations identified in this region. The medium value assigned to the Hamma Hamma River is for a waterfall that prevents access to some upstream area. The rest of Hood Canal (Big Quilcene River, west Kitsap and lower west Hood Canal frontal) was assigned a low value, as it does not support independent populations. The primary management activities that may affect the PCEs (section 2.2) with high conservation value include: channel modifications/diking, forage fish/species harvest, forestry and the Cushman Dam on the Skokomish River (NMFS 2005b).

2.2.2.2. Status of Critical Habitat for Puget Sound steelhead

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

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

2.2.2.3. Status of Critical Habitat for Hood Canal Summer Chum Salmon

The critical habitat designation for Hood Canal summer chum salmon includes 12 watersheds accessible to listed chum salmon (including estuarine areas and tributaries) draining into Hood Canal as well as Olympic Peninsula rivers between and including Hood Canal and Dungeness Bay, Washington. Also included are estuarine/marine areas of Hood Canal, Admiralty Inlet, and the Strait of Juan de Fuca to the international boundary and as far west as a straight line extending north from Dungeness Bay (65 FR 7764, NMFS & NOAA 2000). Excluded are areas above Cushman Dam in the Skokomish River Basin or above longstanding, naturally impassable barriers in the above, defined area (i.e., natural waterfalls in existence for at least several hundred years).

The conservation value of most critical habitat was ranked as high. Exceptions include the Skokomish River and the upper west Hood Canal frontal—the former for the severe degradation of the habitat and the latter for the small size and limited distribution of summer chum present relative to other areas. The primary management activities that may affect the PCEs (section 2.2) include: channel modifications/diking, forage fish/species harvest, agriculture, forestry, urbanization, and road building/maintenance (NMFS 2005b).

2.2.3. **Climate Change**

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

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

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

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

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

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

2.3. **Environmental Baseline**

Under the Environmental Baseline, NMFS describes what is affecting listed species and designated critical habitat before including any effects resulting from the Proposed Action. The “Environmental Baseline” includes the past and present impacts of all Federal, state, or private actions and other human activities in the Action Area, 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). The effects of future actions over which the Federal agency has discretionary involvement or control will be analyzed as “effects of the action.”

2.3.1. **Habitat**

Habitat actions in Hood Canal include shoreline development, transportation, forest practices, and agriculture within the Quilcene, Dosewallips, Duckabush, Hamma Hamma, and Skokomish subbasins on the west side and the Port Gamble, Big Beef-Anderson, Tahuya-Dewatto, and Union-Mission subbasins of the eastern and southern portions of Hood Canal (Correa 2002; Correa 2003; Kuttel 2003). Activities associated with shoreline development include habitat filling, shoreline armoring, removal of riparian habitat, fragmentation of eelgrass beds, and installation of various artificial structures (i.e., boat ramps). Throughout Hood Canal, shallow bays, lagoons, and salt marshes, which provide juvenile rearing and transition habitat, have been altered or lost (Correa 2003; Kuttel 2003).

The development of three major roads have affected salmon habitat in Hood Canal. Highway State Route 101 extends South to North along the entire west shore and has shortened tidal sloughs and tributary channels in larger estuaries and has impacted smaller estuaries by reducing tidal influence and estuary function (Correa 2003). On the eastern side of Hood Canal, road density exceeds 3 miles of road for 1 square mile of watershed, which is the threshold for significant watershed impairment—State Route 106 and Northshore Road in particular have altered floodplain habitat at stream mouths (Kuttel 2003). The U.S. Forest Service has decommissioned many roads on the west side of Hood Canal along with restoration of riparian buffers and instream habitat complexity.

Logging in Hood Canal began in the mid-1800s, but, in the1950s, Washington Department of Fisheries started a program aimed at improving stream habitat associated with logging practices. These efforts have resulted in recovery of most affected watersheds and have helped sustain the commercial forest products industry, which is the dominant land user on the eastern side of Hood Canal. The U.S. Park and Forest Services have also modified their forest practices to selectively thin versus clear-cut forests. In addition, the U.S. Forest Service has implemented a Riparian Reserve program, which ensures canopy cover for temperature control, large woody debris recruitment, stable streambanks, and migration corridors (Correa 2003). However, increased urbanization associated with population growth, an approximate doubling in size in both Kitsap and Mason Counties, has led to an increase in the conversion of forestlands to residential development (Kuttel 2003).

Agricultural practices in Hood Canal include channelization, drained beaver ponds for livestock grazing, and reductions in riparian zones. These activities have resulted in reductions of juvenile rearing and overwintering habitat associated with beaver ponds, increased streambank stability and sedimentation loads, and decreased channel complexity. These practices have been most widespread on the west side of Hood Canal (Correa 2002; Correa 2003).

There is one major hydropower project located on the North Fork Skokomish River. This development includes two dams, Cushman 1 and Cushman 2, constructed in 1926 and 1932, respectively. There are currently no fish passage facilities at the project, which has limited access to salmon and trout habitat above river mile 15.6. Since the completion of Cushman Dam 2 until 1999, the lower North Fork Skokomish River has been dry four miles downstream to McTaggert Creek because the entire flow was diverted to Powerhouse No. 2. Since April 1999, Tacoma Power has released about 60 cubic feet per second (cfs) downstream, allowing salmon and trout access to habitat in most of the lower North Fork Skokomish River (NMFS 2004b).

The Pacific Northwest Salmon Habitat Project Database, maintained by the Northwest Fisheries Science Center, contains information on the approximately 118 projects that have occurred in the Hood Canal. Of the 118 projects, 89 focused on habitat restoration, 13 improved fish passage and 16 involved land or easement acquisition. Included in this project list are restoration of the Dosewallips, Duckabush, and Skokomish estuaries, which have likely improved habitat for both listed Chinook salmon populations in Hood Canal (PNSHP 2015, accessed April 9, 2015). Projects in Hood Canal have been funded and implemented, in part, through the Pacific Coastal Salmon Recovery Fund (PCSRF), established by Congress to help protect and recover salmon and steelhead populations and their habitats (NMFS 2007b). 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 (e.g., Washington State Salmon Recovery Funding Board) to foster development of Federal-state-tribal-local partnerships in salmon and steelhead recovery.

2.3.2. **Fisheries**

The HGMPs indicate that all hatchery programs in the Puget Sound region would operate consistent with the *U.S. v. Washington* (1974) fisheries management framework. This legal framework requires measures for coordinating State and tribal implementation of agreed hatchery programs. This fisheries resource co-management process requires that both the State of Washington and the Puget Sound Tribes cooperate and agree on the function, purpose, and fish production strategies for all Puget Sound hatchery programs (Hood Canal Salmon Management Plan 1986; Puget Sound Salmon Management Plan 1985).

Within Hood Canal, recreational and treaty and non-treaty commercial fisheries for non-listed, hatchery-origin species produced through the programs may incidentally affect natural-origin Chinook and summer chum salmon and steelhead (i.e., Hoodsport Hatchery Chinook, pink, coho, and fall chum salmon). Despite the eight segregated programs' purpose for producing fish for harvest, fisheries are not considered interrelated with or interdependent on these programs because the programs are not the sole producers of fish for the fisheries. The Hood Canal Steelhead supplementation program is also not interrelated or interdependent with fisheries because the program propagates listed steelhead. There are no fisheries directed at or managed for harvest of listed steelhead.

However, because management of the Chinook salmon fishery follows a weak stock management scheme, adult Chinook salmon produced by the Hamma Hamma Supplementation Program are interrelated and interdependent with management of the Puget Sound Chinook salmon fishery. Management is based on a weak-stock approach, with the mid-Hood Canal population representing one of the stocks with abundance criteria that help decide annual harvest management, which may limit fisheries when mid-Hood Canal population abundances are low. The Hamma Hamma program propagates fish from the mid-Hood Canal population, thereby helping maintain population levels more conducive to harvest implementation.

NMFS determined (NMFS 2001; NMFS 2014b) that implementing and enforcing the harvest components of the resource management plans for summer chum and Chinook salmon (Bureau of Indian Affairs 2014; WDFW and PNPTT 2000) would have little measurable effect on the listed populations.

2.3.3. **Hatcheries**

In 2000, the SCSCI provided guidelines for summer chum supplementation programs within Hood Canal to minimize adverse genetic and demographic effects on listed summer chum salmon as well as ecological effects on other listed-species. These guidelines included modified juvenile release timing and size, release of only seawater ready life stages, and delayed broodstock collection timing for fall chum, to reduce interactions with listed summer chum. In addition, most supplementation programs were terminated after 12 years of operation (3 generations). These measures are likely contributing to the increase in abundance, diversity, and productivity of summer chum detailed in section 2.2.3.1. The effects of Federal and non-Federal hatchery programs on summer chum were evaluated by NMFS and determined to not reduce the likelihood for survival and recovery of the ESU (NMFS 2002).

The measures implemented for summer chum also likely benefit other salmon and trout, such as the release of seawater ready life stages to limit competition between hatchery and natural fish. In 2004, a number of hatchery programs were further modified after managers considered the recommendations of the Hatchery Salmon Review Group (HSRG 2004). These modifications included reductions in release numbers and in some cases program terminations (Table 9). In addition, the HSRG broadly recommended external marking for Chinook salmon programs to monitor the straying of hatchery-origin spawners into natural spawning areas and to allow for selective harvest of hatchery fish.

Table 9. Hatchery Programs within Hood Canal (HC). An asterisk indicates programs that are part of the Proposed Action.

Species	Program	Begin Date	Location	Release Number/Life Stage	Alterations
Chinook Salmon	Big Beef Creek	1993	Big Beef Creek East HC	200,000 subyearlings	Terminated in 2003
	George Adams	1961	Skokomish River	3.8 million subyearlings	None
	Hoodsport*	1953	Finch Creek, west HC	3 million subyearlings 250,000 yearlings	Reduced to 120,000 yearlings
	Rick's Pond	1995	Skokomish River	120,000 yearling	Terminated in
	South Sound Chinook Salmon		Skokomish River	200,000	Terminated in 2004
	Hamma Hamma* Supplementation	1995	Hamma Hamma River	110,000 subyearlings	Reduced to 95,000
Fall Chum	Quilcene National Fish Hatchery	1912	Big Quilcene River, West HC	2.2 million fry	Terminated in 2004
	Hoodsport*	1954	Finch Creek, west HC	15 million fry	Reduced to 12 million
	McKernan	1978	Skokomish River	10 million fry	None
	Port Gamble*	1976	Little Boston Creek	950,000 fry	None
	Enetai Creek*	1976	Enetai Creek	3.2 million fry	None
Summer Chum	Union/Tahuya supplementation	2000	Union and Tahuya Rivers	352,000 fry	None
	Lilliwaup Creek supplementation	1992	Lilliwaup Creek	168,000 fry	None
	Hamma Hamma River supplementation	1997	Hamma Hamma River	125,000 fry	Terminated in 2006

	Big Beef Creek reintroduction	1996	Big Beef Creek	86,000 fry	Terminated in 2000
	Big Quilcene River supplementation	1992	Big Quilcene River	300,000 fry	Terminated in 2003
Pink Salmon	Hoodsport*	1953	Finch Creek, west HC	1 million fry	Reduced to 500,000
Coho Salmon	George Adams	1961	Skokomish River	500,000	Reduced to 200,000
	Quilcene National Fish Hatchery*	1912	Big Quilcene River	400,000 yearlings	None
	Quilcene Net Pens*	1986	Quilcene Bay	200,000 yearlings	None
	Port Gamble Net Pens*	1981	Port Gamble Bay	400,000 yearlings	None
Steelhead	Eells Springs	1976	Skokomish River	50,000 yearlings	Terminated in 2004
	Hood Canal* Supplementation	2007	Dewatto, Duckabush, Skokomish Rivers	48,567 yearlings 883 adults	Ended in 2014
	Hamma Hamma Supplementation	1998	Hamma Hamma River	5,000 yearlings 200 adults	Ended in 2008

Sources: HCCC 2005; SSPS 2005; Berejikian et al. 2008; PSDEIS 2014

2.4. **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. NMFS follows the methodology and best scientific information for analyzing hatchery effects summarized in section 2.4.1. Application of the methodology and analysis of the Proposed Action follows in section 2.4.2. The “effects of the action” means how the direct and indirect effects of the action, together with the effects of other activities that are interrelated or interdependent, on individuals within the population may affect population(s) VSP parameters and designated critical habitat. Indirect effects are caused by the Proposed Action 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.

2.4.1. **Factors Considered When Analyzing Hatchery Effects**

NMFS has substantial experience with hatchery programs and has developed and published a series of guidance documents for designing and evaluating hatchery programs following best available science. These documents are available upon request from NMFS SFD in Portland, Oregon.

- Pacific Salmon and Artificial Propagation under the Endangered Species Act (Hard et al. 1992)
- Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units(McElhany et al. 2000)
- Salmonid Hatchery Inventory and Effects Evaluation Report (NMFS 2004d)

- In 2005, NMFS published a policy that provided greater clarification and further direction on how it analyzes hatchery effects and conducts extinction risk assessments (NMFS 2005c).
- NMFS then updated its inventory and effects evaluation report for hatchery programs on the West Coast (Jones Jr. 2006) and followed that with
- Artificial Propagation for Pacific Salmon: Assessing Benefits and Risks & Recommendations for Operating Hatchery Programs Consistent with Conservation and Sustainable Fisheries Mandates (NMFS 2008).
  Biological analysis and final determination for the harvest of Puget Sound Chinook salmon, which included discussion on the role and effects of hatchery programs (NMFS 2011b)

NMFS' analysis of the Proposed Action is in terms of effects, both positive and negative, the Action would be expected to have on ESA-listed species and designated critical habitat, based on the best scientific information available. 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 viable salmonid population (VSP) parameters or attributes; abundance, productivity, spatial structure, and diversity. NMFS 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.

The effects of a hatchery program on the status of an ESU or steelhead DPS depends on which of the four VSP parameters are currently limiting the ESU, and how the hatchery fish within the ESU affect each parameter (NMFS 2005c). Hatchery programs can positively affect population viability, but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). The presence of hatchery fish within the ESU can positively affect the overall status of the ESU by; increasing the number of natural spawners, serving as a source population for repopulating unoccupied habitat and increasing spatial distribution, and by conserving genetic resources. Hatchery fish can negatively affect an ESU/DPS by reducing adaptive genetic diversity, and reducing the reproductive fitness and productivity (NMFS 2005c). The range in effects for a specific hatchery program are refined and narrowed after consideration of available scientific information and the unique circumstances and conditions of an individual hatchery program. The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 10.

NMFS subdivides hatchery programs into two major types; integrated and isolated (i.e., segregated). Hatchery programs that are reproductively connected or "integrated" with a natural population, if one still exists, and that promote natural selection over selection in the hatchery, contain genetic resources that represent the diversity of a species and are included in an ESU or steelhead DPS. When a hatchery program actively maintains distinctions or promotes differentiation between hatchery fish and fish from a native population, then NMFS refers to the program as "isolated." Isolated hatchery programs have a level of genetic divergence, relative to the local natural population(s), that is more than what occurs within the ESU and are not considered part of an ESU or steelhead DPS. Isolated programs promote domestication or selection in the hatchery over selection in the wild. These programs select for and culture a stock of fish with different phenotypes (e.g., different ocean migration timing, and spatial and temporal spawning distribution) compared to the native population (extant in the wild, in a hatchery, or both).

Information that NMFS needs to analyze the effects of a hatchery program on ESA-listed species must be included in an HGMP. NMFS reviews all draft HGMPs 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 seven 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
(4) Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean
(5) RM&E that exists because of the hatchery program
(6) The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program
(7) 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. The categories are:

(1) Positive or beneficial effect on population viability
(2) Negligible effect on population viability
(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 VSP status, the role or importance of the affected natural population(s) in recovery, the target viability for the affected natural population(s), and the Environmental Baseline including the factors currently limiting population viability.

Table 10. Range in effects on natural population viability parameters from 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 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 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).

2.4.1.1. 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 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
- The pros and cons of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock
- The maximum number of fish proposed for collection
- The proportion of the donor population used for hatchery broodstock

"Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure.However, rearing offspring from natural-origin broodstock in a hatchery likely improves the survival from the egg to release stage as compared to offspring reared naturally. For example, steelhead researchers found that survival from egg to smolt in the hatchery was 85-90 percent compared with 1-5 percent for offspring reared naturally (Reisenbichler et al. 2004 in Araki et al. 2008). Also considered here is whether the program "backfills" with fish from outside the local or immediate area.

NMFS considers the physical process of collecting hatchery broodstock and the effect of the process on ESA-listed species under Factor 2.

2.4.1.2. 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 at this time, based on 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 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 the risks mentioned above may be outweighed when 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 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, 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 2011b).

2.4.1.2.1. 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-influenced 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 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 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 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 (Gharrett and Shirley 1985; Withler 1988). 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). 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.

Inbreeding depression, another N_e-related phenomenon, is caused by the mating of closely related individuals (e.g., sibs, half-sibs, 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. 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 a 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)[3] among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before 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 taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Blankenship et al. 2007; Saisa et al. 2003). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Leider et al. 1990; 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

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

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. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported multiple-generation effects. Critical information for analysis of hatchery-influenced 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-influenced selection includes the number, location and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish[4]. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS, Figure 2).

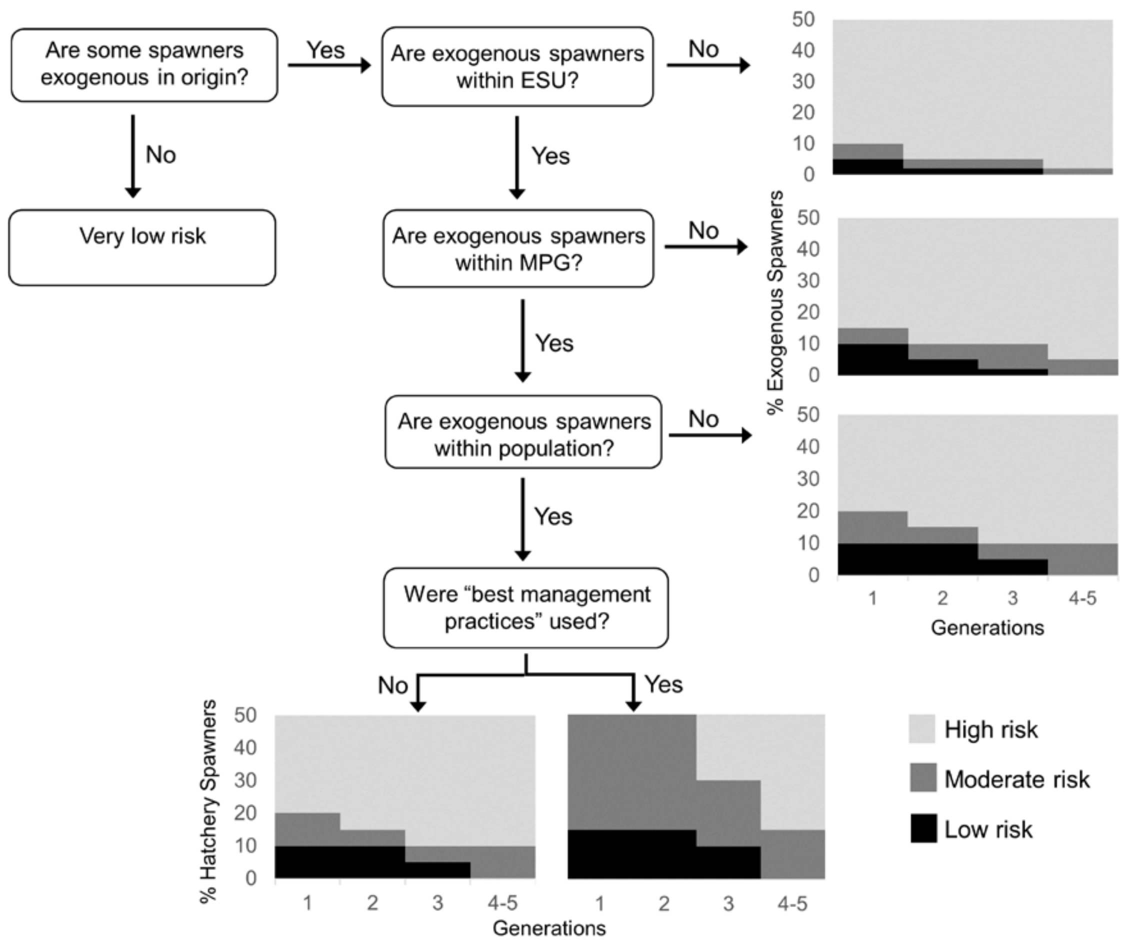

Figure 2. Risk of maintaining natural patterns of gene flow associated with spawner composition and number of generations (modified from ICTRT 2007). Exogenous fish are all hatchery-origin fish, and non-normative strays of natural origin.

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 isolated programs are based on pHOS, but guidelines for

[4] 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.

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 (pNOB)[5]. PNI is in theory a reflection of the relative strength of selection in the hatchery and natural environments: a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. For a population of high conservation importance their guidelines are a pHOS of no greater than 5% for isolated 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 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) in which they stated that the guidelines for isolated programs may not provide as much protection from fitness losss 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 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%. 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.

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 (HSRG 2009, appendix C) they introduce a new term, *effective pHOS*. Despite these inconsistencies, their overall usage of pHOS indicates

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[5] 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.

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.

NMFS concludes that if pHOS guidelines are used in analysis of genetic hatchery effects, the pHOS metric should as much as possible represent gene flow potential, therefore pHOS should be considered the *effective* proportion of hatchery-origin spawners in the natural spawning population. Thus, the "census" pHOS should be adjusted as appropriate for RRS or other factors limiting the success of hatchery-origin spawners to yield a value closer to the true expected gene flow, or "effective pHOS". This adjustment should not be done indiscriminately, however. As discussed above, enough research has been done to conclude that hatchery-origin spawners are generally less successful in the wild than natural spawners, but unless population-specific information is available, assumptions about effectiveness should be conservative.

A simple analysis of the expected proportions of mating types provides additional perspective on pHOS (Figure 3), shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly[6]. For example, when pHOS is 10%, 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.

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

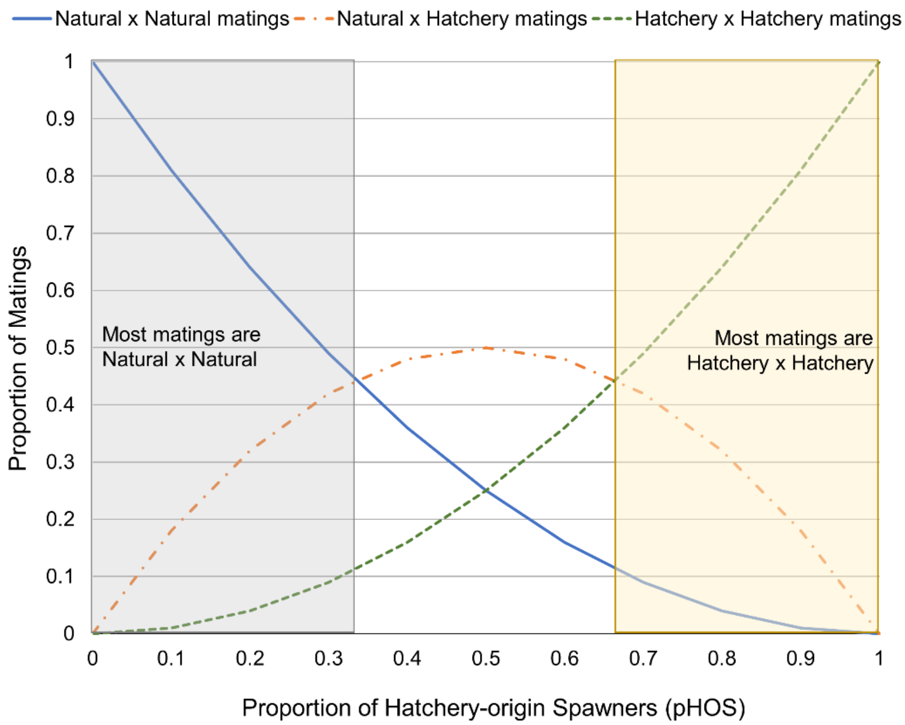

Figure 3. Relative proportions of mating types as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS).

2.4.1.2.2. Ecological effects

Ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refers to effects from competition for spawning sites, 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—hatchery-origin and natural-origin alike—return to spawn, 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 gravel 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 when there is spatial overlap between hatchery and natural spawners because the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima et al. 1998).

2.4.1.2.3. Adult Collection Facilities

The analysis also considers the effects from encounters with natural-origin fish that are incidental to the conduct of 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 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. 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- and hatchery-origin fish that are intended to spawn naturally and to 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, remove hatchery fish from the river or stream, and/or prevent hatchery fish from spawning naturally. This includes effects on fish, juveniles and adults, from encounters with these structures and effects on habitat conditions that support and promote viable salmonid populations. NMFS wants to know, for example, if the spatial structure, productivity, or abundance of a natural population is affected when fish encounter a structure used for broodstock collection. NMFS also analyzes changes to riparian habitat, channel morphology and habitat complexity, water flows, and in-stream substrates attributable to the construction/installation, operation, and maintenance of these structures.

2.4.1.3. Factor 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. The level of effect for this factor ranges from neutral to negative.

2.4.1.3.1. Competition

Competition and a corresponding reduction in productivity and survival may result when hatchery-origin fish interfere directly with the accessibility to limited resources (e.g., space, food) by natural-origin fish (NMFS 2012). Competition may also occur indirectly when the utilization of a limited resource by hatchery fish reduces the amount available for the natural fish population (SIWG 1984). For example, natural fish may be competitively displaced by hatchery fish when hatchery fish are more numerous. Hatchery fish might alter natural 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 natural salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural 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).

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 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 due to more similar resource use, 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-influenced 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 natural-origin rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and natural 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 is definitely a consideration, 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 near hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

The risk of 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 natural-origin fish in freshwater (California HSRG 2012; Steward and Bjornn 1990)
- Rearing hatchery fish to a size where smoltification occurs in nearly the entire population
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing by natural-origin juveniles
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location and timing if substantial competition with natural-origin juveniles is determined to be likely

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the Action Area. 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.

2.4.1.3.2. 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 (direct consumption) 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 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, habitat is limited, and environmental conditions favor high visibility.

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 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 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 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 in 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 natural 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 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.

2.4.1.3.3. Disease

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. 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)—which has only been identified in Japan where masou salmon (*Oncorhynchus masou)* are endemic—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):

- 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 from natural populations. 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 (Steward and Bjornn 1990; Naish et al. 2008). This is because both hatchery and natural 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), making it difficult to eliminate pathogen exposure.

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), removal of mortalities, and disinfection of all eggs. Vaccines may provide additional protection from certain pathogens. 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; in such a case, if an epizootic occurs, 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. This practice limits the presence of fish susceptible to pathogen infection to prevent 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., ozone; Naish et al. 2008). Although preventing the exposure of fish to any pathogens prior to their release into the natural environment may make them more susceptible to infection, reduced fish densities in the natural environment compared those in 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 when their effluent mixes with saltwater, killing pathogens before they can be transmitted to fish.

Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., a low level of dissolved oxygen). Hatchery facilities routinely use a variety of chemicals for treatment and sanitation purposes. Chlorine levels, 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 monitors settleable and unsettleable solids, temperature and dissolved oxygen 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. The exception to this are diseases caused by nutritional deficiencies, which are expected to occur rarely if ever in current hatchery operations due to the vast literature available on successful rearing of salmon and trout in aquaculture.

2.4.1.3.4. 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 of hatchery juveniles before release. Acclimation of hatchery juveniles before release increases the probability that hatchery adults will home back to the release location reducing their potential to stray into natural spawning areas. Dittman and Quinn (2008) provide an extensive literature review and introduction to homing in Pacific Salmon. They note that as early as the 19th century marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2013). Fisheries managers use this innate ability for salmon and steelhead to home to specific streams when using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated as well as a way to provide for fisheries (Dunnigan 2000; Quinn 1997; YKFP 2008).

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 this measure include: (1) timing the acclimation when a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation; (2) whether the water source attracts returning adults; (3) whether the hatchery fish can access the stream reach where they were released; and (4) whether the water quantity and quality is such that returning hatchery fish will hold in that area before removal and/or their harvest in fisheries

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 to reduce straying into other areas (Bentzen et al. 2001; Fulton and Pearson 1981; Hard and Heard 1999; Kostow 2009; Kostow 2012; Quinn 1997; Westley et al. 2013), although it does not always show a clear benefit (e.g., (Clarke et al. 2011; Kenaston et al. 2001). Acclimating fish also allows them to recover from the stress due to transporting the fish to the release location and from handling.

2.4.1.4. Factor 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 and, while there is evidence that large-scale hatchery production can effect 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 watch for new research to discern and to measure the frequency, the intensity, and the 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. Factor 5. 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.

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 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 designated critical habitat
(2) Critical uncertainties over effects of the Proposed Action on the species
(3) The effectiveness of the hatchery program at achieving its goals and objectives
(4) Identifying and quantifying collateral effects
(5) Tracking compliance 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 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.

2.4.1.6. Factor 6. 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. It 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 and habitat complexity, in-stream substrates, and water quantity and water quality attributable to operation, maintenance, and construction activities and 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 to negative.

2.4.1.7. Factor 7. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis of HGMP effects in a section 7 consultation. One is where there are fisheries that exist because of the HGMP (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 ESU or steelhead DPS from spawning naturally. The level of effect for this factor ranges from neutral to negative.

Some atchery programs can produce more fish than are needed for the conservation and recovery of an ESU. However, these fish 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 may 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 2005c). Regardless, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.

2.4.2. **Effects of the Proposed Action**

Analysis of the Proposed Action identified that within the Action Area, ESA-listed species are likely to be negatively affected from six of the seven factors described in Section 2.4.1. The analysis of these effects is described below.

The analysis of effects on Hood Canal Summer Chum Salmon are only limited to the Hood Canal Steelhead Supplementation Program because the effects of the other nine programs on Hood Canal Summer Chum salmon were previously evaluated by NMFS (2002), and are therefore included in the environmental baseline (Section 2.3.3).

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

Table 11. Overall effect of broodstock on listed species.

Listed ESU/DPS	Effect	
	Integrated	Segregated
Puget Sound Chinook Salmon	Negative	Negligible
Puget Sound Steelhead	Negligible	Negligible
Hood Canal Summer Chum Salmon	Not Applicable	Not Applicable

Of the 10 programs encompassed by this Opinion, only the Hamma Hamma Fall Chinook Salmon Supplementation program and the Hood Canal Steelhead Supplementation Program rely or have relied on broodstock collection practices involving listed species: Puget Sound Chinook salmon and steelhead. Because the remaining programs have no current or past reliance on using natural-origin broodstock, they have no effects to discuss under Factor 1.

Puget Sound Chinook Salmon

The primary goal for the integrated Hamma Hamma Chinook salmon supplementation program is restoration of a viable, self-sustaining, natural-origin mid-Hood Canal salmon population by using supportive breeding to preserve and restore the population. The pNOB goal for the proposed integrated program is between 0 and 50 percent (0-30 fish), depending on how many natural-origin fish returning to the Hamma Hamma River can be caught. Although this is a small number, the abundance of the natural origin population in mid-Hood Canal is also very small and taking 30 natural-origin fish from a return of 75 natural-origin fish could result in too few natural spawners available to result in any natural x natural matings. Limiting collection of natural-origin fish for broodstock to 33 percent of the run ensures that the majority of natural-origin fish is left to spawn naturally and provides at least some opportunity for natural x natural matings.

Puget Sound Steelhead

The collection of eyed eggs from natural-origin steelhead redds allows for natural mate choice. By collecting only a portion of each redd, the genetic contribution of each female to natural production is maintained. The high egg-to-release survival in the hatchery suggests collected eggs are not damaged, but any damage to uncollected eggs disturbed during collection is unknown (Berejikian et al. 2011). Although damage to uncollected eggs is a concern, the program stopped collecting eggs in 2014, and do not propose to do so into the future.

Hood Canal Summer Chum Salmon

None of the programs propagate Hood Canal summer chum salmon. Therefore, no natural-origin summer chum salmon are removed from the system for broodstock purposes.

2.4.2.2. 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

Table 11. Overall effect of hatchery fish on spawning grounds on listed species.

Listed ESU/DPS	Effect	
	Integrated	Segregated
Puget Sound Chinook Salmon	Beneficial	Negligible
Puget Sound Steelhead	Beneficial	Negligible
Hood Canal Summer Chum Salmon	Negligible	Not Applicable

This factor considers genetic, ecological and broodstock collection effects. However, genetic effects are limited to those programs that propagate the same species as the listed species. For Chinook salmon the programs that could have potential genetic effects are the Hamma Hamma Supplementation and Hoodsport hatchery Chinook salmon programs. For steelhead, this is the Hood Canal Steelhead Supplementation program and for summer chum salmon, no programs are expected to have genetic effects. Ecological and broodstock collection effects are an indirect outcome of a hatchery program and thus some of these effects are anticipated for all ten programs.

Puget Sound Chinook Salmon

The integrated Hamma Hamma Chinook salmon supplementation program has the potential to result in hatchery-influenced selection that may reduce fitness of hatchery fish compared to natural-origin Chinook salmon. However, the fish returning to the Hamma Hamma Suplementation program are not genetically distinct from natural-origin Chinook salmon in the Hamma Hamma River or from hatchery fish returning to George Adams Hatchery in the Skokomish River (Long Live the Kings et al. 2013). In addition, the current abundance is below the critical abundance threshold of 200 fish (Ruckelshaus et al. 2002). The average return for the population from 2000 to 2012 was 175 fish, with ~50 percent of the fish attributed to the supplementation program (Downen 2015; Long Live the Kings et al. 2013). Thus, the major risk to the natural Chinook salmon population in Hood Canal is not a genetic one from the supplementation program, but a demographic one without the supplementation program.

Because of the limited numbers of natural-origin fish, the program has no proposed pHOS standard because all returning fish are intended to spawn naturally. For now, this is a reasonable approach considering the demographic risk. However, when abundance increases above the critical threshold, a pHOS target consistent with the HSRG recommendation of 30 percent would help ensure that more natural fish are spawning than hatchery fish to limit hatchery-influenced selection. Without the program, the abundance of natural-origin fish in the wild (~75 currently; NWFSC 2015) would likely decrease and could lead to adverse effects associated with small population sizes, including lack of mates and inbreeding. Therefore, in order to minimize the take of listed salmonids, NMFS is including in its terms and conditions below a requirement that pHOS be limited to no more than 30 percent once the population has reached the critical threshold. The pHOS calculation will be determined using a five-year running average of years in which the critical threshold is met and/or exceeded.

Straying of Chinook salmon from the Hoodsport Hatchery program (which are not considered part of the listed ESU) could potentially adversely affect listed Chinook salmon through outbreeding depression as well as competition for spawning sites and redd superimposition. However, outbreeding depression is not a concern because Chinook salmon from the Hamma Hamma River and Hoodsport are genetically similar and the percentage of Hoodsport Chinook salmon that do not return to Finch Creek is low, with an average (2002-2009) of 1.9 and 5 percent of adults returning from the subyearling and yearling program components, respectively (Table 14). This equates to less than four fish per year straying into the listed Chinook populations in Hood Canal (Marston 2015); 2 percent or less of the receiving population's composition. This is in line with the HSRG recommendation of 5 percent pHOS from segregated programs into each independent population. Low straying also reduces potential for competition and redd superimposition because few hatchery fish would be present in the area.

The ecological effects of competition for spawning sites and redd superimposition on Chinook salmon are negligible for the Hood Canal Steelhead Supplementation Program because steelhead return timing and spawning occur much later than for fall Chinook salmon (Table 13). The effects of broodstock collection from the steelhead supplementation program on listed Chinook salmon are negligible because only eggs are collected and collection occurs after completion of the Chinook salmon run.

Non-listed chum, pink, and coho salmon adults originating from the segregated hatchery programs that escape to natural spawning areas may compete with Chinook salmon for spawning sites and superimpose their redds on Chinook salmon redds. Coho salmon stray rates are low, with less than 5 percent of the fish straying from all three programs combined (Table 14). We are unable to estimate stray rates for pink and fall chum salmon because fish are not marked to distinguish them from natural-origin fish. However, any effects associated with pink salmon spawning are limited to odd-numbered years only; there is no even-year pink salmon population in Hood Canal. Overlap with fall chum is likely only to occur in October, after the peak of the natural-origin portion of the Chinook salmon run (Table 13). In addition, none of the segregated programs release fish into rivers or streams where listed independent Chinook salmon populations are established.

Broodstock for the Hoodsport Chinook, pink, and fall chum salmon programs are collected from fish that return to any local hatchery. Any listed Chinook salmon encountered in the weir are released. From 2004 to 2008, ESA-listed mid-Hood Canal Chinook salmon from the Hamma Hamma Supplementation program were collected in Finch Creek and spawned as part of the broodstock for the Hoodsport Chinook salmon program (Table 12). Since then, WDFW corrected this practice through education of hatchery staff on the identification and treatment of ESA-listed species (Christina Iverson, WDFW, pers. comm.), and no listed Chinook salmon have been encountered since 2008. However, with every hatchery program there is some small percentage of hatchery-origin fish that are released unmarked, which prevents them from being identified as hatchery-origin fish. Without any way to identify these fish as hatchery origin, they look and will be treated like natural fish. With marking rate errors of about 0.5 percent, about 100 returning Chinook salmon adults would fall into this category. In addition, the likelihood of ESA-listed natural-origin Chinook salmon in Enetai, Finch, or Little Boston Creeks is low because these small creeks are unable to support fish as large as Chinook salmon.

Table 12. Listed species encountered during Hoodsport Hatchery salmon broodstock collection.

Year	Puget Sound Chinook Salmon	Puget Sound Steelhead
2004	5	-
2005	39	-
2006	21	0
2007	5	2
2008	2	0
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	1
2014	0	0
2015	0	0
Mean	6	0.3
Mode	1	0

Quilcene National Fish Hatchery collects coho broodstock for all three coho programs in the Quilcene River where listed fish are present. This stock has an earlier run time than natural coho (August through late October as opposed to mid-September to mid-November), which may increase overlap with listed Chinook salmon (Table 13). No Chinook salmon have been encountered in the weir over the last 15 years (USFWS 2015). Thus, broodstock collection practices and straying from the segregated programs are likely to have negligible effects on listed Chinook salmon.

Table 13. Timing of adult return and spawning.

Species	Freshwater Entry	Spawn Timing
Chinook salmon (fall)	July to October	Peaks in mid-October (hatchery); August (natural)
Coho salmon	Mid-September to mid-November	November to mid-January

Steelhead trout (winter)	December to May	February to June
Pink salmon (odd-year)	Early August to October	September to October; peak in mid-October
Chum salmon (summer)	Early August to September	Late August to early October
Chum salmon (fall)	Early October to Early January	Late October to January

Source: (WDFW and PNPTT 2000; WDFW and WWTIT 1994)

Puget Sound Steelhead

Hatchery-influenced selection may occur through the operation of the steelhead supplementation program. However, these effects are minimized by rearing only natural-origin steelhead eggs collected from natural redds. Any fish returning from the supplementation program are therefore natural in origin and allowed freedom of mate choice, limiting hatchery-influenced selection to potential domestication effects. The return of hatchery-reared fish would also serve to increase population abundance and at least preserve, if not increase, genetic diversity of the listed population. Analysis of five years of data for a previous steelhead supplementation study in the Hamma Hamma River showed that neither the genetic diversity of the populations nor the effective population size were negatively affected by the supplementation program (Van Doornik et al. 2010). However, it may be that a reduction in effective population size only becomes evident after several generations (Waples and Teel 1990). Because steelhead population sizes are well below intrinsic potential in Hood Canal, the demographic risk to the populations of not having enough spawners is of greater concern than the potential genetic risk to the populations of mating with fish that may have some degree of domestication. However, when the five-average population abundances reach 750 individuals, the operators would need to confer with NMFS on genetic effects.

Competition for spawning habitat and redd superimposition associated with fish straying from the other nine programs are unlikely to occur with Puget Sound steelhead because all other salmon species have returned and spawned prior to the timing of the steelhead return (Table 13). Broodstock for the Hoodsport Chinook, pink, and fall chum salmon programs are collected from fish that return to the hatchery. Any listed fish encountered in the weir are released. The likelihood of listed-fish in Enetai, Finch or Little Boston Creeks is low due to the small creek size. Within the last ten years, three steelhead have been encountered during broodstock collection at Hoodsport hatchery (Table 12; Christina Iverson, WDFW, pers. comm.). One steelhead has been encountered in the Quilcene National Fish Hatchery weir over the last 15 years (USFWS 2015). Because the Hamma Hamma Chinook Salmon Supplementation Program uses hook and line and seine for broodstock collection, which are more targeted both spatially and temporally. Thus, broodstock collection practices for the programs would be expected to encounter few, if any, steelhead.

Hood Canal Summer Chum Salmon

The effects on summer chum salmon from hatchery-reared steelhead on the spawning grounds is negligible because there is little if any overlap in run and spawn timing for these two stocks (Table 13). The effects of broodstock collection for the steelhead supplementation program on natural-origin summer chum is negligible because of complete separation in timing and location of spawning between the species, and collection of eggs for broodstock ended in 2014.

Table 14. Straying rates from segregated programs.

Species	Program	Mean Adult Escapement[1]	% Strays[2]	Mean Adults Harvested[1]
Coho	Quilcene National Fish Hatchery Yearling Coho Salmon	8,251 ± 4,686 (1989-2008)	0.2	8,609 ± 5,654
	Port Gamble Coho Net Pen	256 ± 47 (2000-10)	2.4	6,482 ± 3,545
	Quilcene Bay Coho Net Pen	1,433 ± 1,518 (1988-2011)	0.1	8,231 ± 5,182
Fall Chinook-not in ESU	Hoodsport Hatchery Fall Chinook	3,759 ± 1,153 (2001-13)	1.9 subyearling 5.0 yearling	17,136 ± 9,624
Pink	Hoodsport Hatchery Pink Salmon	14,884 ± 9,369 (2007-11)	Unknown	2,689 ± 2,407
Fall Chum	Hoodsport Hatchery Fall Chum	10,873 ± 7,207 (2008-11)	Unknown	150,196 ± 89,486
	Port Gamble Hatchery Fall Chum	2,977 ± 2,210 (2000-10)	Unknown	3,065 ± 3,065
	Skokomish Enetai Creek Hatchery Fall Chum	5,720 ± 4,073 (1988-2011)	Unknown	17,238 ± 11,792

[1] Sources: (Port Gamble S'Klallam Tribe 2013a; Port Gamble S'Klallam Tribe 2013b; Skokomish Tribe 2013a; Skokomish Tribe 2013b; USFWS 2015; WDFW 2013a; WDFW 2013b; WDFW 2014; WDFW 2015)
[2]Source: Gary Marston (Marston 2015)

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

Table 15. Overall effect of hatchery fish in juvenile rearing areas on listed species.

Listed ESU/DPS	Effect	
	Integrated	Segregated
Puget Sound Chinook Salmon	Negligible	Negligible
Puget Sound Steelhead	Negligible	Negligible
Hood Canal Summer Chum Salmon	Negligible	Not Applicable

2.4.2.3.1. Releases of Hatchery Fish

2.4.2.3.1.1.Disease

The hatchery programs would be operated in compliance with state co-manager and USFWS fish health protocols pertaining to movement and monitoring of cultured fish (NWIFC and WDFW

2006; USFWS 2004). High egg-to-release survival rates for fish propagated in the hatchery programs that are part of the proposed action (averages range from 72-95 percent across all programs) indicate that protocols for monitoring and addressing the health of fish in hatcheries have been effective at limiting mortality. In addition, the hatchery facilities included in this analysis are typically located at or near the confluence of the river or creek and Hood Canal. This relatively quick mixing with marine water limits the lifespan of pathogens that may be present in hatchery effluent. Coho salmon in the net pen programs historically suffered from endemic *Vibrio anguillarum* epizootics with the increase in temperatures in the spring, but vaccination for this pathogen prior to moving fish into the pens has controlled epizootics (Port Gamble S'Klallam Tribe 2013a; Skokomish Tribe 2013a). For these reasons, fish pathogen transmission and amplification risks associated with HGMP implementation for all programs would occur at low levels, if at all.

2.4.2.3.1.2.Competition and Predation

Puget Sound Chinook Salmon

Competition and predation effects on listed Puget Sound Chinook salmon may occur with the release of hatchery fish. The release of pink and fall chum salmon is likely to serve as prey for the subyearling Chinook, which are about twice the size. Supplemented steelhead trout smolts may feed on juvenile Chinook, but because the annual release of supplemented steelhead was less than 50,000 with no smolt releases occurring after 2016, predation in the past has likely ranged from a few dozen to 14,000 subyearlings a day, not all of which would be Chinook salmon (Table 18). With the end of smolt releases, there is no effect of this program on Chinook salmon in juvenile rearing areas into the future.

Hatchery coho salmon also present a predation threat, but coho salmon releases into the Big Quilcene River or directly into Hood Canal are spatially segregated from the natural-origin Chinook salmon in the Dosewallips, Duckabush and Hamma Hamma Rivers. The release of hatchery Chinook salmon may also provide additional adverse competition and predation effects on natural-origin Puget Sound Chinook salmon. However, the peak in natural-origin Chinook salmon out-migration is in March (NMFS 2014a), before the release of hatchery Chinook salmon from April to June (Table 16). Hatchery fish also tend to migrate out of freshwater quickly when smoltification has occurred. For example, juvenile out-migrant trapping in the lower Dungeness River showed that about 99.7 percent of the hatchery yearling Chinook salmon released migrated past the river mouth within seven days (Topping et al. 2008). In addition, Hoodsport Hatchery releases their Chinook salmon directly into Hood Canal, minimizing any potential freshwater interaction. Thus, the effects of the juvenile fish released through the segregated programs on natural-origin Chinook salmon in freshwater are negligible.

Table 16. Estimated size and freshwater occurrence/release for natural and hatchery juvenile salmonids.

Species (Origin)	Life Stage	Estimated Size (mm fl)	Occurrence/Release Timing
Chinook salmon (wild)	Fry	< 45	January-April
Chinook salmon (wild)	Parr	45-110	April-February

Chinook salmon (wild)	Yearling	76-156	February-May
Chinook salmon (hatchery)	Sub-yearling	88-97	late April-mid June
Chinook salmon (hatchery)	Yearling	190-220	late April-mid May
Steelhead (wild)	Fry	< 40	May-October
Steelhead (wild)	Parr	50-150	October-mid May
Steelhead (wild)	Smolt	159-235	February-June
Steelhead (hatchery)	Smolt	100-170	mid April-mid May
Steelhead (hatchery)	Adult	< 254	February-May
Coho (wild)	Fry	< 60	March-May
Coho (wild)	Parr	60-85	May-April
Coho (wild)	Yearling	90-115	late April-May
Coho (hatchery)	Yearling	75-90	late April-May
Fall Chum (wild)	Fry	< 50	February-May
Fall Chum (hatchery)	Fry	50-53	April
Summer Chum (wild)	Fry	37-41	December-early April
Pink (wild)	Fry	32-43	March-April
Pink (hatchery)	Fry	50-53	April-May

Sources (Hard et al. 1996; Kinsel and Zimmerman 2011; Myers et al. 2014; Piper et al. 1986; Topping and Zimmerman 2013; WDFW and PNPTT 2000; Weinheimer et al. 2011; Weitkamp et al. 1995)

Puget Sound Steelhead

Predation effects as a result of the proposed action are expected to be minimal. The size of listed hatchery steelhead smolts at release is generally at least twice the size of fish released from the other nine proposed programs. Natural-origin steelhead smolts are also typically larger than fish released from the other nine programs (Table 16). This size difference limits predation on and competition with hatchery steelhead by other species of hatchery fish. Yearling Chinook and coho salmon are the most likely hatchery fish released that could compete with steelhead smolts directly because of their similar size. However, the release of Hoodsport Hatchery Chinook salmon and coho salmon from Quilcene during the latter part of the natural-origin steelhead outmigration time (late April to June) as seawater ready smolts directly into Hood Canal and the first three river miles of the Big Quilcene River respectively, limits potential competitive interactions both temporally and spatially (also see section 2.4.2.4). Thus, we concluded that hatchery fish in freshwater juvenile rearing areas have a negligible effect on Puget Sound steelhead.

Hood Canal Summer Chum Salmon

The effect on Hood Canal summer chum in juvenile rearing areas is expected to be negligible because the release of steelhead smolts is delayed until late-April-May when most summer chum have emigrated out of rearing areas; typically from December to early April with a peak in March (WDFW and PNPTT 2000). This release timing is in accordance with the NMFS (2002) Opinion, which required all releases of hatchery fish to take place after April 15th, to avoid the majority of the natural-origin summer chum salmon emigration. In addition, chum salmon emigration out of freshwater where the fish may be most vulnerable to predation typically occurs within just a few days of emergence (Fresh 2006).

2.4.2.3.2. Progeny of naturally-spawning hatchery fish

The ISAB recently released a report (based on Columbia River populations) that summarizes the adverse density-dependent effects hatchery production can have on natural salmon populations. One example is that salmon densities that exceed habitat capacity may lower salmon productivity beyond replacement (ISAB 2015). To apply this to Hood Canal, the first step in assessing this potential adverse effect is to determine the carrying capacity of a particular geographic area. This should be based on current habitat conditions and conditions going forward, rather than what the historical population size was, as habitat loss and degradation may have eroded the historical carrying capacity.

Carrying capacity has been estimated for the mid-Hood Canal Chinook salmon population using the Ecosystem and Diagnostic Tool (WDFW and PNPTT 2005). However, this tool only provides estimates of adult carrying capacity, not juvenile carrying capacity. In addition, the tool was initially developed to direct and assess the effectiveness of habitat restoration projects, and was not meant to develop quantitative estimates of carrying capacity. More consideration is needed to understand what the drawbacks may be in using this tool for a different purpose than what was intended (e.g., are uncertainties in the data fully considered).

Currently, none of the available data suggests that exceedance of carrying capacity is limiting salmon and steelhead populations. Given the uncertainty over the use of the available tool, additional attention is given to the need to closely monitor and evaluate the continued validity of that assumption. Further, it will be useful in the future to have a method available that assesses program size in the context of current carrying capacity to ensure that natural production is not limited by hatchery production. Likewise, this information could also support increasing hatchery production to take full advantage of available habitat. As habitat restoration projects improve habitat, carrying capacity estimates can be revisited to ensure program size is still appropriate under improved habitat conditions.

2.4.2.4. Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, in the estuary, and in the ocean

Table 17. Overall effect of hatchery fish in the migration corridor, estuary, and ocean on listed species.

Listed ESU/DPS	Effect	
	Integrated	Segregated
Puget Sound Chinook Salmon	Negligible	Negative
Puget Sound Steelhead	Negligible	Negative
Hood Canal Summer Chum Salmon	Negligible	Not Applicable

Puget Sound Chinook Salmon

Chinook salmon generally prey upon fish one-half their length or less (Beauchamp and Duffy 2011; Brodeur 1991). Assuming this is similar among all salmon and trout species, only the hatchery yearling steelhead, coho, and Chinook salmon are big enough in size to prey upon listed natural-origin Chinook salmon. In a literature review by Naman and Sharpe (2012), predation of hatchery yearlings on subyearlings ranges from <0.001 to approximately 0.5 subyearlings per day. Thus, yearling Chinook and coho salmon may consume thousands of subyearlings daily (Table 18).

Table 18. Numbers of subyearling salmon and steelhead consumed daily by hatchery Chinook and coho salmon and steelhead yearlings/smolts based on the equation and assumptions in Naman and Sharpe (2012).

Predation Rate (subyearlings/hatchery fish)	Chinook salmon (120,000 released)	Coho Salmon (1,000,000 released)	Steelhead (50,000 released)
0.001	66	554	28
0.005	332	2770	139
0.01	665	5539	277
0.05	3323	27695	1385
0.1	6647	55390	2770
0.5	33234	276950	13850

NMFS must also consider residence time of the Chinook and coho salmon; longer residence times are more likely to increase total subyearling consumption. Coho smolts are thought to move out of the estuary and into the open ocean within a week (Simenstad et al. 1982 in Fresh 2006). In contrast, there is a high probability that yearling Chinook salmon from Hoodsport hatchery will residualize within Hood Canal. Chamberlin et al. (2011) showed that all but one of the 41 tagged yearling Chinook salmon remained within Hood Canal for the entire duration of the study (~150 days). A population reconstruction scenario suggested that several hundred thousand Chinook salmon of ages 1-3 reside in Puget Sound for most or all seasons of the year and could consume 6 to 59 percent of the 15-18 million juvenile Chinook salmon (Beauchamp and Duffy 2011). The current annual release of 120,000 yearling Chinook salmon could represent a large percentage of the resident Chinook salmon, if most of these fish residualize as the Chamberlin et al. (2011) study suggests. Over the lifetime of these fish, yearling releases could pose an adverse predation effect on juvenile natural-origin Chinook salmon.

Puget Sound Steelhead

Steelhead in the migration corridor and estuary are the same size as or larger than other migrating juveniles, limiting their vulnerability to predation. Because supplemented steelhead reside in Hood Canal for about two weeks after release (Moore et al. 2010), competition could occur between steelhead and the similarly sized Chinook and coho salmon smolts. Moore et al. (2010) found that steelhead early marine survival depended more on the distance traveled than on residence time, with a longer travel distance associated with higher mortality. This might be due to competition for space and food not being as limiting as the vulnerability of steelhead to large predators (e.g., seals, birds). Another potential predator is Chinook salmon released from Hoodsport hatchery that residualize in Hood Canal, because they will be large enough to consume steelhead smolts after a few years of residency in Hood Canal.

Hood Canal Summer Chum Salmon

The effects on summer chum from supplemented steelhead trout in the migration corridor and estuary are likely negligible. This is because summer chum fry emigrate earlier in the year than much of the steelhead release and because the annual release of supplemented steelhead smolts is relatively small.

2.4.2.5. Factor 5. Research, monitoring, and evaluation that exists because of the hatchery program

Table 19. Overall effect of RM&E on listed species.

Listed ESU/DPS	Effect by Program Type	
	Integrated	Segregated
Puget Sound Chinook Salmon	Negligible	Negligible
Puget Sound Steelhead	Negligible	Negative
Hood Canal Summer Chum Salmon	Negligible	Negligible

Puget Sound Chinook Salmon

The primary objective for the integrated Chinook salmon program is to supplement the abundance of Hood Canal populations and ultimately improve species status. The RM&E actions proposed are those that would be implemented to determine whether the proposed program attains this objective.

The assessment of adult abundance and origin through spawning ground surveys and juvenile outmigration through screw trapping may result in adverse effects on listed Chinook salmon. Observation of adults via spawning ground surveys likely only to result in some behavioral changes in adults, such as a startling response, with up to 100 percent of the population affected. However, these effects are only expected to be short in duration and are within the range of normal fish behaviors to unusual stimuli. Therefore, we don't consider them a form of take. The effects of monitoring for juvenile outmigration of the Hamma Hamma Chinook salmon program in the Hamma Hamma River are already covered in WDFW's research permit mentioned in Section 1.4. This monitoring results in unintentional mortality of about one percent of the 3,000 Puget Sound Chinook salmon (hatchery and natural-origin) encountered annually. No additional sampling is proposed for this hatchery program. All RM&E could potentially be difficult to interpret if biologists are unable to distinguish between hatchery- and natural-origin fish. However, masking of the mid-Hood Canal Chinook salmon population status is not a concern because of the close to 100 percent marking of Chinook salmon from both the integrated and segregated Chinook salmon programs. Because few adults are likely to be harmed, no additional monitoring of juveniles is proposed, and masking is not a concern, effects of RM&E on Chinook salmon is expected to be negligible.

Puget Sound Steelhead

The primary objectives for the integrated steelhead program are to increase the abundance of multiple populations within the DPS and to assess the demographics and life history of these same populations. The study is likely to result in the annual handling of 14,400 (about 50 percent natural-origin, naturally-reared) juvenile steelhead and 170 (50 natural-origin, naturally-reared) adult steelhead in the Dewatto, Tahuya, Skokomish, and Little Quilcene Rivers. Incidental mortality is estimated at 34 juveniles and 4 adults from all locations combined.

Research is also being conducted in the Hamma Hamma and Duckabush Rivers and Big Beef Creek, with juvenile handling amounting to about 1,500 hatchery-reared natural-origin smolts and 1,950 naturally-reared natural-origin smolts, covered by the research permits mentioned in Section 1.4. Incidental mortality from permitted research already considered elsewhere is estimated at 50 juveniles and 7 adults from all locations.

The expertise and oversight of researchers who have conducted similar sampling limits the adverse effects and informs the amount of sampling required to answer demographic and life history questions. There may also be some adverse effects on critical habitat through redd sampling, but the degree of habitat disturbance is limited to foot traffic. In addition, the entire research program is proposed to end in 2023, limiting these RM&E effects to the next eight years; no effects of these RM&E activities are expected to occur after conclusion of the research.

The only other proposed program likely to encounter listed steelhead during research and monitoring is the Quilcene NFH yearling coho salmon program during operation of their screwtrap for non-listed juvenile salmonid sampling, and during snorkel and foot surveys. Past trap operation has resulted in the capture of about two juvenile steelhead per year with no mortality, and this level of encounter is expected to continue. Foot and snorkel surveyors have encountered steelhead adults/redds and make every effort to avoid them if possible (USFWS 2015).

Hood Canal Summer Chum Salmon

The effects of RM&E associated with the integrated steelhead program on summer chum are negligible. Winter steelhead spawn later than summer chum (Table 13), which limits disturbance to summer chum redds during counting of steelhead redds. Although sampling for natural steelhead parr and smolts, proposed for April though the end of summer, may overlap initially with the presence of summer chum fry, summer chum would be released into the river if caught.

2.4.2.6. Factor 6. Construction, operation, and maintenance of facilities that exist because of the hatchery programs

Table 20. Overall effect of operation, maintenance and construction of hatchery facilities on listed species.

Listed ESU/DPS	Effect	
	Integrated	Segregated
Puget Sound Chinook Salmon	Negligible	Negligible
Puget Sound Steelhead	Negligible	Negligible
Hood Canal Summer Chum Salmon	Negligible	Not applicable

The majority of the water supply systems used for salmon and steelhead rearing in the proposed programs are designed and operated so that groundwater extraction and surface water diversion are not expected to reduce survival, spatial distribution, and productivity of natural-origin salmon and steelhead. Although the Hoodsport, Port Gamble, and Enetai Creek hatchery intake structures do not currently meet screening criteria (NMFS 2011a), listed fish are not likely to occur in the creeks where surface water is drawn.

All water used by the hatcheries would be returned near the points of withdrawal (Table 5) resulting in no net loss in river or tributary flow volume. No stream reaches would be dewatered to the extent that natural-origin fish migration and rearing would be impaired. Although NPDES permits are in place to monitor solids and chemicals in effluent, there is no mechanism to test for pathogen amplification stemming from hatchery effluent. However, by adhering to fish health guidelines (NWIFC and WDFW 2006; USFWS 2004) pertaining to sanitation and disease prevention as well as disinfection in the event of a disease outbreak, we believe the risk of pathogen amplification is minimized. Thus, the negative effects of hatchery facility operation and maintenance on listed fish are negligible as long as the facilities comply with Federal and State permits, fish health policies, water rights, and NMFS screening criteria.

2.4.2.7. Factor 7. Fisheries that exist because of the hatchery program

The effects of fisheries on ESA-listed species have been previously evaluated for compliance under the ESA (NMFS 2011b) and are included in the Environmental Baseline. Thus, there are no additional adverse effects because of the Proposed Action.

2.4.2.8. Effects of the Action on Critical Habitat

Designated critical habitat features likely affected in the Hood Canal region are water quantity and quality associated with water withdrawals, operation, and maintenance activities, and effluent return to the streams. The proposed hatchery programs include strict criteria for diverting water from the river and the quality of the effluent. These criteria include water rights, NPDES permits and associated routine monitoring, and fish health protocols to minimize pathogen amplification (section 1.3) and are all currently met and adhered to by the proposed hatchery programs. Operation and maintenance activities would include pump maintenance, debris removal from intake and outfall structures, building maintenance, and ground maintenance. These activities are not expected to degrade water quality or adversely modify designated critical habitat because they occur infrequently and result in minor temporary effects. The construction of new facilities or reconstruction of in-river hatchery structures is not considered in this opinion and would require separate consultation. For these reasons, the operation of the hatchery programs as proposed will have a negligible effect on PCEs and PBFs in the Action Area.

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). For the purpose of this analysis, the Action Area is described in section 1.4. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the Environmental Baseline (whether they are Federal, state, tribal, or private). To the extent those same activities are reasonably certain to occur in the future (and are tribal, state, or private), their future effects are included in the cumulative effects analysis.

Recovery Plans

The Federally approved recovery plans for Puget Sound Chinook salmon (NMFS 2006a; SSPS 2005) and Hood Canal summer chum salmon (HCCC 2005; NMFS 2007a) describe the on-going and proposed state, tribal, and local government actions designed to reduce known limiting factors on listed species in the Hood Canal region. Although a recovery plan for Puget Sound steelhead has yet to be developed, many of the actions implemented for Chinook and summer chum salmon recovery will also benefit steelhead. We expect the recovery activities identified in the baseline to continue at similar magnitudes and intensities as in the recent past. The Proposed Action would likely continue to lessen the effects of non-Federal land and water use activities on the status of listed fish species. However, the actions must be funded, in the process of implementation (most are not), and sustained in a comprehensive manner before NMFS can consider them "reasonably foreseeable" in its analysis of cumulative effects. Specific actions to recover listed salmon and steelhead in Puget Sound watersheds have included:

- Updating and adopting Federal, state, and local land use protection programs to cover existing habitat and habitat-forming processes
- More effectively combining regulatory, voluntary, and incentive-based protection programs
- 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
- Protective instream flow programs to reserve sufficient water for salmon production
- Protective actions on agricultural lands.

With these improvements, there is also the potential for adverse cumulative effects associated with some non-Federal actions to increase (Judge 2011).

Hatcheries

The future effects of ongoing hatcheries in Hood Canal that are reasonably certain to occur in the future (and are WDFW-managed and funded), are included in the cumulative effects analysis even if the ongoing WDFW-managed activities may become the subject of ESA take determinations or permits in the future. The effects of such activities are treated as cumulative effects unless and until an opinion for the determination or permit has been issued. The continued propagation of fall Chinook, coho, pink and chum salmon for harvest will likely increase adverse competition effects in the future on listed salmon and trout, tempered by continued habitat improvements.

Pacific Coastal Salmon Recovery Fund

The PCSRF was established by Congress to help protect and recover salmon and steelhead populations and their habitats (NMFS 2006b). The states of Washington, Oregon, California, Idaho, and Alaska, and the 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; the effects of projects completed by the states and tribes are included in the environmental baseline.

NOAA Restoration Center Programs

NMFS has completed ESA consultation on the activities of the NOAA Restoration Center in the Pacific Northwest (NMFS 2004a). These include participation in the Damage Assessment and Restoration Program, Community-based Restoration Program (CRP), and the Restoration Research Program. The CRP is a financial and technical assistance program that helps communities to implement habitat restoration projects. Projects are selected for funding based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration—to the extent that such actions have been consulted on, they are reflected in the environmental baseline description; the effects of projects not yet consulted on are not considered in this analysis.

2.6. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS adds the effects of the Proposed Action (section 2.4.2) to the Environmental Baseline (2.3) and to Cumulative Effects (2.5) to formulate the agency's opinion as to whether the Proposed Action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat. This assessment is made in full consideration of the status of the species and critical habitat and the status and role of the affected population(s) in recovery (sections 2.2.1, 2.2.2, and 2.2.3).

In assessing the overall risk of the Proposed Action on each species, NMFS considers the risks of each factor discussed in section 2.4.2. in combination, considering their potential additive effects with each other and with other actions in the area (Environmental Baseline and Cumulative Effects). This combination translates the threats posed by each factor of the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciably reduce the likelihood of survival and recovery of the listed species and their designated critical habitat.

2.6.1. Puget Sound Chinook Salmon

The Puget Sound Chinook Salmon ESU recovery criteria require at least two viable populations in each biogeographical region. Thus, viability of the mid-Hood Canal population is needed for the Hood Canal region and ESU recovery. However, the current population abundance (175 average spawners) is well below the abundance target for the population under either low (5200) or high (1300) productivity scenarios.

The proposed programs have made substantial changes since their inception, including reduced juvenile release numbers and delay of juvenile release until fish are sea-water ready. Although the changes were instituted to minimize adverse effects on natural-origin summer chum, they likely also benefit ESA-listed Chinook salmon. In addition, numerous habitat improvement projects are underway in Hood Canal and revisions in Puget Sound fisheries management include explicit incidental fishing limits for the mid-Hood Canal population.

Analysis indicates that, although there are some potentially negative genetic effects on Chinook salmon associated with broodstock collection and hatchery fish on the spawning grounds, these negative effects are outweighed by the benefit of increased abundance from the Hamma Hamma Chinook salmon supplementation program. In addition, the straying rate of Chinook salmon from the segregated program outside of the ESU is low (1.3 percent). The effects of hatchery fish in juvenile rearing areas and in the migratory corridor and estuary were negligible due to the minimization measures instituted for summer chum described above. However, the presence of residual Hoodsport hatchery Chinook salmon likely has a negative effect. RM&E effects were negligible as the monitoring proposed is needed to ensure program objectives are met and fish are 100 percent marked to ensure hatchery and natural fish can be differentiated during monitoring. Lastly, we considered the effects of hatchery operations and maintenance negligible, because is it likely that no listed fish are present in water bodies where hatcheries with unscreened intakes operate.

Puget Sound Steelhead

A Federally approved recovery plan for Puget Sound steelhead does not exist. However, all four steelhead populations within the Hood Canal are below their intrinsic potential. The Environmental Baseline indicated that in addition to the changes made to the proposed programs mentioned above for summer chum, there was a previous supplementation program for steelhead that was shown to increase abundance on the Hamma Hamma River. In addition, the habitat projects mentioned above will likely also benefit steelhead trout. In contrast to Chinook salmon, fisheries for steelhead are mostly recreational and tribal, and have been limited since steelhead listing.

Analysis indicated that broodstock collection for steelhead, in the form of eggs from natural-origin redds minimizes genetic risks associated with spawning broodstock in the hatchery and with hatchery-reared fish spawning naturally. The effects of hatchery fish in juvenile rearing areas and in the migratory corridor and estuary were negligible due to the minimization measures instituted for summer chum described above and the large size of steelhead smolts at release. Thus, hatchery fish are an unlikely source of prey for other species of hatchery fish or competitor for other species due to occupancy of a different niche. The one exception is for Hoodsport hatchery Chinook salmon that may residualize in Hood Canal, potentially leading to a negative effect. RM&E effects were negative, but NMFS believes that the understanding gained about steelhead life history and genetics from the proposed steelhead supplementation program outweighs the risks associated with in-stream surveys and tissue sampling. Lastly, the effects of hatchery operations and maintenance were considered negligible, because it is likely that no listed fish are present in water bodies where hatcheries with unscreened intakes operate.

Hood Canal Summer Chum Salmon

The status of the Hood Canal Summer Chum Salmon ESU is improved compared to previous years in terms of both abundance and productivity. The multiple supplementation and reintroduction programs within Hood Canal have attempted to recapture the abundance, spatial structure and diversity of the multiple spawning aggregations within the population. The hatchery program modifications and habitat projects mentioned in the Environmental Baseline have likely contributed to the increased abundance and spatial structure. A revised fishing regime that prohibits target fisheries and limits incidental catch for summer chum has also likely contributed to the increase in summer chum abundance.

Analysis was limited to the effects of just the Hood Canal steelhead supplementation program on summer chum as a previous biological opinion addressed effects on summer chum from the other nine programs (NMFS 2002). In addition, because steelhead are a different species, no genetic effects occur on summer chum, thus limiting the analysis to ecological effects. Our analysis identified only negligible effects on summer chum because steelhead adult run timing and spawning occurs later than summer chum and no broodstock are collected for the steelhead program. In addition, the release of steelhead is delayed until summer chum have emigrated seaward.

2.6.2. **Critical Habitat**

In reviewing the Proposed Action and after conducting the effects analysis, NMFS has determined that it will not degrade critical habitat. 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 and no new facilities or changes to existing facilities are proposed. The Proposed Action includes strict criteria for withdrawing and discharging water used for fish rearing, and these actions will not have any discernible effect or result in any adverse modification of critical habitat.

2.6.3. **Climate Change**

The Chinook salmon and steelhead populations in Hood Canal may be adversely affected by climate change (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 reduce spring and summer flows, impairing water quantity and water quality in primary fish rearing habitat. Predicted increases in rainfall would increase the frequency and intensity of floods in the freshwater tributaries of Hood Canal, leading to scouring flows that would threaten the survival and productivity of natural-origin listed fish species. The proposed programs may 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. It is unlikely that the programs would exacerbate the effects of climate change because they divert water over short distances and then that water is returned to the same water source.

2.7. **Conclusion**

After reviewing the current status of the listed species, the Environmental Baseline within the Action Area, the effects of the Proposed Actions, including effects that are likely to persist following expiration of the Proposed Actions, and cumulative effects, it is NMFS' biological opinion that the Proposed Actions are not likely to jeopardize the likelihood of survival and recovery of the Puget Sound Chinook Salmon ESU, the Hood Canal Summer Chum Salmon ESU, the Puget Sound Steelhead DPS, or to destroy or adversely modify critical habitat where designated for these species.

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. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. For purposes of this consultation, we interpret "harass" to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or significantly altered[7]. 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 this Incidental Take Statement (ITS).

2.8.1. **Amount or Extent of Take**

NMFS analyzed seven factors applicable to the proposed hatchery salmon actions that are likely to result in take of listed Puget Sound Chinook salmon and Puget Sound steelhead. No Hood Canal summer chum take is anticipated associated with the steelhead supplementation program (WDFW and LLTK 2012).

Tables 21 and 22 show the amount of take associated with broodstock collection (Factors 1 and 2), facility operations (Factor 6) and RM&E (Factor 5).

Table 21. Annual quantifiable take of Puget Sound Chinook salmon.

Hatchery Program	Puget Sound Chinook Salmon			
	Observed/Harassed	Captured, Handled, Released (Mortality)	Incubation/ Rearing Mortality[1]	Broodstock (direct take)
Hamma Hamma Fall Chinook Supplementation	100 adult	18 (2) adult	13,100 (egg-juvenile)	Up to 60 adult[2]
Hood Canal Steelhead Supplementation	0	1,000 (25) juvenile	NA	NA
Quilcene National Fish Hatchery Yearling Coho Salmon Production	0	2 juvenile 2 adult	NA	NA
Hoodsport Hatchery Fall Chinook	0	100 (5) adult	NA	NA

[7] NMFS has not adopted a regulatory definition of harassment under the ESA. The World English Dictionary defines harass as "to trouble, torment, or confuse by continual persistent attacks, questions, etc." The U.S. Fish and Wildlife Service defines "harass" in its regulations as an intentional or negligent act or omission that creates 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 (50 CFR 17.3). The interpretation we adopt in this consultation is consistent with our understanding of the dictionary definition of harass and is consistent with the USFWS interpretation of the term.

Hoodsport Hatchery Fall Chum	0	5 adult	NA	NA
Hoodsport Hatchery Pink Salmon	0	2 adult	NA	NA
Port Gamble Coho Net Pen	0	0	NA	NA
Port Gamble Hatchery Fall Chum	0	2 adult	NA	NA
Quilcene Bay Coho Net Pen	0	0	NA	NA
Skokomish Enetai Creek Hatchery Fall Chum	0	2 adult	NA	NA

[1]Calculated using information from Table 3. Survivial of ESA-listed fish during incubation and rearing.Table 3; number of eggs collected multiplied by survival rate.
[2]No more than 33 percent of the natural-origin escapement estimate for the mid-Hood Canal population can be taken for broodstock.

Table 22. Annual quantifiable take of Puget Sound steelhead.

Hatchery Program	Puget Sound Steelhead			
	Observed/Harassed	Captured, Handled, Released (Mortality)	Incubation / Rearing Mortality	Broodstock
Hamma Hamma Fall Chinook Supplementation	0	2 adult	NA	NA
Hood Canal Steelhead Supplementation	6,000 eggs	14,600[1] (40) juvenile 170[1] (7) natural adult	NA	NA
Quilcene National Fish Hatchery Yearling Coho Salmon Production	4,000 eggs 50 juvenile 5 adult	5 juvenile 4 adult	NA	NA
Hoodsport Hatchery Fall Chinook	0	2 adult	NA	NA
Hoodsport Hatchery Fall Chum	0	2 adult	NA	NA
Hoodsport Hatchery Pink Salmon	0	0	NA	NA
Port Gamble Coho Net Pen	0	0	NA	NA
Port Gamble Hatchery Fall Chum	0	0	NA	NA
Quilcene Bay Coho Net Pen	0	0	NA	NA
Skokomish Enetai Creek Hatchery Fall Chum	0	2 adult	NA	NA

[1]About 50 percent of the juveniles are of natural-origin and naturally-reared. 50 adults are natural-origin, naturally-reared.

Factor 2: Genetic and Ecological Effects

In addition to the take from broodstock collection, Factor 2 includes effects on genetic diversity, and NMFS has identified incidental take through that pathway for the proposed action. Effects of hatchery fish on the genetics of natural-origin fish can occur through a reduction in genetic diversity, outbreeding depression, and hatchery-influenced selection. Take due to these genetic effects cannot be directly measured because it is not possible to observe gene flow or interbreeding between hatchery and wild fish in a reliable way.

With respect to fall Chinook salmon, NMFS will therefore rely on a surrogate for an indication of the level of incidental take: pHOS. This is the appropriate indicator of take because limiting the number of hatchery-origin fish on the spawning grounds also limits the amount of spawning site competition and redd superimposition that can occur between hatchery and natural-origin fish. Therefore, the take surrogate is logically related to take from genetic and ecological effects. In years when the average natural-origin population abundance for the most recent twelve years remains under the critical value of 200, pHOS for the Hamma Hamma Fall Chinook Salmon program will be limited to the difference between the natural-origin returns and an overall population abundance target of 300 spawners[8]. Once the critical value is exceeded, pHOS will be limited to the HSRG recommendation of 30 percent. The take surrogate can be reliably measured and monitored through spawning ground surveys.

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

Factors 3 and 4: Juvenile fish in rearing areas, migration corridor, estuary and ocean

Competition with and predation by residual hatchery-origin Chinook salmon and coho smolts could result in take of natural-origin Chinook salmon and steelhead within the fresh and marine waters of the Hood Canal region. However, it is difficult to quantify this take because ecological interactions cannot be observed. Thus, the surrogate take variable for this take pathway is the date of yearling smolt release. This standard has a rational connection to the amount of take expected from ecological interactions because adverse ecological interactions increase the more overlap there is between hatchery and natural-origin fish. For this take surrogate, releases of yearling coho and Chinook salmon smolts should take place after the majority of natural-origin Chinook salmon and steelhead have exited the system, which is around the end of March. NMFS considers, for the purpose of this take surrogate, that hatchery yearling smolts cannot be released prior to April 15th. If there is a need to release hatchery yearling Chinook salmon and coho prior to this date, the operator has to consult with NMFS to show information that doing so will not increase the temporal overlap with natural-origin fish. Absent this showing, releases before April 15 will be considered to have exceeded the level of incidental take. In addition, release numbers must not exceed those proposed in the HGMPs by greater than 10 percent. The take surrogate can be reliably measured and monitored through enumeration and tracking of release dates for hatchery yearling Chinook and coho salmon. If NMFS receives information that the emigration of a majority of natural-origin juveniles has shifted to a later time, NMFS will revisit this take surrogate.

[8] For example, if natural-origin spawners = 50, then 250 hatchery fish can spawn naturally to meet the 300 spawner target. In this case, pHOS would equal 83 percent.

2.8.2. **Effect of the Take**

In section 2.7, NMFS determined that the level of anticipated take, coupled with other effects of the Proposed Actions, are not likely to jeopardize the continued survival of Puget Sound Chinook salmon, Hood Canal summer chum salmon, Puget Sound steelhead or result in the destruction or adverse modification of their designated critical habitat.

2.8.3. **Reasonable and Prudent Measures**

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). "Terms and conditions" implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in section 7(a)(2) to apply. NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. This opinion requires that the Action Agencies (NMFS, USFWS and the BIA):

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

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) will lapse. This Opinion requires that the Action Agencies:

1.

- 1a. Conduct surveys/assessments to determine the migration timing, abundance, distribution, and origin (hatchery and natural) of Chinook salmon and steelhead spawning naturally as described in the HGMPs.
- 1b. Use current monitoring data and/or conduct new monitoring as necessary to assess juvenile carrying capacity for the action area based on current habitat conditions.
- 1c. Conduct surveys/assessments of coho, fall chum, and pink salmon as described in the HGMPs to monitor and report on any redd superimposition or spawning site competition observed where listed Chinook salmon and summer chum salmon and steelhead spawn naturally.

1d. Provide annual estimates of recruits per spawner, escapement, and straying of Chinook salmon from the Hamma Hamma Fall Chinook Salmon Supplementation Program and the Hoodsport Fall Chinook Hatchery Program and steelhead from the Hood Canal Supplementation Program by origin (hatchery or natural).

1e. Maintain the percentage of Hoodsport hatchery Chinook salmon below the HSRG guideline of 5 percent of the total spawners in the Hamma Hamma, Dosewallips, and Duckabush Rivers (HSRG et al. 2004).

1f. Maximum releases should not exceed 10 percent of the proposed release numbers.

1g. Releases of yearling Chinook salmon and coho salmon should not occur prior to April 15th.

1h. Limit the natural-origin broodstock used in the Hamma Hamma Chinook Salmon Supplementation program to 33 percent of the escapement estimate for the mid-Hood Canal Chinook Salmon population.

1i. Limit the most recent five-year average pHOS to no more than 30 percent in the Hamma Hamma River when abundance for the mid-Hood Canal Chinook salmon population exceeds the critical threshold value of 200 natural-origin fish. The average should only include the most recent five-years in which the pHOS restriction applies (i.e., when natural-origin abundance exceeds 200 fish).

2.

2a. Immediately release unharmed any listed salmon or steelhead incidentally encountered in the course of salmon broodstock collection operations at the point of capture. Record the number, location, and condition of any listed salmon or steelhead encountered during collection.

3.

3a. Implement the hatchery programs as described in the HGMPs. Notify NMFS's Sustainable Fisheries Division (SFD) in advance of any change in hatchery program operation and implementation that potentially would result in increased take of ESA-listed species.

3b. Notify NMFS as soon as any take thresholds are exceeded within two days of exceedance.

4. Provide an annual report to NMFS SFD on or before April 1st that includes the RM&E described in Terms and Conditions 1-3. All reports and notifications shall be submitted either electronically or by post to the SFD point of contact for this Opinion:

Charlene Hurst (503) 230-5409, charlene.n.hurst@noaa.gov
NMFS – Sustainable Fisheries Division
Anadromous Production and Inland Fisheries Branch
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 two conservation recommendations appropriate to the Proposed Action:

1. Halt the release of coho above Quilcene National Fish Hatchery until studies determine if there is a natural coho run present in the Big Quilcene River to preserve the genetic diversity of any natural stock.

2. Screen all unscreened intakes even within water bodies where listed fish are not expected to occur to better ensure authorized take limits are not exceeded.

2.10. **Re-initiation of Consultation**

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 Actions 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 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 descriptions of EFH for Pacific coast salmon (PFMC 2003) 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**

EFH for Pacific Chinook, coho and pink 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). In estuarine and marine areas, salmon EFH extends from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the exclusive economic zone (200 nautical miles) offshore of Washington, Oregon, and California north of Point Conception (Pacific Fishery Management Council 2014). Within these areas, EFH 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 Action Area (Figure 1, section 1.4) of the Proposed Action includes habitat described as EFH for Chinook, pink, and coho salmon. Other fish species for which EFH has been designated in the Action Area, but that would not be measurably affected by the Proposed Action, are identified in Appendix Table 1. EFH aspects that might be affected by the Proposed Action include effects of hatchery operations on adult and juvenile fish migration corridors; ecological and genetic effects in spawning areas; and ecological effects in rearing areas for the species.

3.2. **Adverse Effects on Essential Fish Habitat**

The Pacific Fishery Management Council (2003) recognized concerns regarding the “genetic and ecological interactions of hatchery and wild fish … [which have] been identified as risk factors for wild populations.” Adverse genetic effects for Chinook salmon associated with implementing the integrated Chinook salmon program is negligible because natural-origin fish in the Hamma Hamma River are used as broodstock when possible. When returns are so low they hinder broodstock collection, eggs from George Adams Hatchery are used, which are not genetically different from Chinook salmon in the Hamma Hamma River. Although fish that stray from the Hoodsport Chinook salmon program are not genetically different from either George Adams hatchery or Hamma Hamma Chinook salmon, they are not included in the ESU (section 2.2.1.1).

Adverse genetic effects also may occur when the hatchery-origin coho and pink salmon stray from the hatchery and spawn naturally. In the case of coho salmon, some hatchery-origin fish are intentionally passed upstream to aid in nutrient enhancement, which may increase the chance of mating with any natural-origin coho. Although the presence of a natural-origin coho run in the Big Quilcene River is unknown, the hatchery return occurs earlier than any other coho return in the Action Area, which may limit mating. For pink salmon, the hatchery releases all fish unmarked, thus the amount of straying and mixing with natural-origin runs is unknown. Thus, the natural spawning of any hatchery-origin Chinook, coho and pink salmon poses an adverse effect on Pacific salmon EFH.

Juveniles’ and naturally spawning adult salmon produced by the proposed hatchery programs may lead to effects on natural-origin salmon EFH through competition, predation and redd superimposition. Competition for food and space and predation on natural-origin juveniles is a potential adverse effect on salmon EFH. However, chum and pink salmon are released at the fry stage; too small to prey on other hatchery salmon species and of a size that may serve as prey for natural-origin Chinook and coho salmon. Competition may occur between hatchery fish and natural-origin Chinook, pink and coho salmon, but is likely limited to marine waters and with sea-water ready natural-origin stages, as all of the proposed hatchery programs release their fish within three river miles of Hood Canal (section 2.4.2.3). Stray adult hatchery-origin salmon may compete with natural-origin salmon for spawning areas and superimpose salmon redds. Although there is some natural temporal and spatial segregation of adult runs and spawning locations, this is still potentially an adverse effect (section 2.4.2.2).

Water withdrawal for the hatchery operations can adversely effect salmon by impeding migration, reducing stream flow, or reducing the abundance of other stream-dwelling organisms that could serve as prey for juvenile salmonids. However, water removed for the operation of the proposed programs is non-consumptive and returned near the point of withdrawal. Water quality can also be affected by hatchery operations, but compliance with the NPDES permit and fish health policies minimizes these effects. Structures used for water withdrawals can also adversely affect salmon EFH by killing or injuring juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment into the water diversion structures. The number and life stage of the migrating salmon populations affected by the intake structures are unknown. Effects associated with the intakes are surmised because the structures at Hoodsport, Enetai Creek, and Port Gamble hatchery are not in compliance with the most recent standards regarding fish passage and screening requirements for instream structures (NMFS 2011a).

3.3. **Essential Fish Habitat Conservation Recommendations**

To address the potential effects of hatchery fish on EFH in natural spawning and rearing areas, the PFMC (2003) provided a recommendation that hatchery programs should, "[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." NMFS believes that the Proposed Action, as described in the HGMPs and the ITS includes the best approaches to avoid or minimize adverse effects on EFH for Chinook, pink and coho salmon. The biological opinion explicitly discusses the potential risks of hatchery fish on natural fish populations and their ecosystems, and describes operation and monitoring appropriate to minimize these risks on Chinook, pink and coho salmon in Hood Canal. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS constitute NMFS recommendations to address potential EFH effects. NMFS, the USFWS and the BIA shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, is carried out. In addition, NMFS suggested four conservation recommendations in section 2.9 that would also be applicable to avoid or reduce adverse impacts on salmon EFH.

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 the statutory reply to the EFH portion of this consultation, each action agency clearly identify the number of conservation recommendations accepted.

3.5. **Supplemental Consultation**

The co-managers 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 10 Hood Canal 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, Port Gamble S'Klallam Tribe, Skokomish Tribe, LLTK and USFWS (operators), and 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 and through the collection of data indicating the potential effects of the operation on the viability of natural populations of Puget Sound Chinook salmon, Hood Canal summer chum 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 NMFS West Coast Region web site (http://www.westcoast.fisheries.noaa.gov). The format and naming adheres to conventional standards for style.

4.2. **Integrity**

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

4.3. **Objectivity**

Information Product Category: Natural Resource Plan

Standards

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

Best Available Information

This consultation and supporting documents use the best available information, as described in the references section. The analyses in this biological opinion/EFH consultation contain more background on information sources and quality.

Referencing

All supporting materials, information, data, and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process

This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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