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 Six Hatchery and Genetic Management Plans for Snohomish River basin Salmon under Limit 6 of the Endangered Species Act Section 4(d) Rule

NMFS Consultation Number: ~~WCR-2012-00841~~ 9-REB NWR-2013-9699

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

Affected Species and Determinations:

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

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

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

Issued By:

FOR Barry A. Thom
Regional Administrator

Date: 9/27/2017

Expires: As per the ESA 4(d) Rule, limit 6, take authorization is open-ended in duration

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1 Introduction

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

The Proposed Actions are: (1) the National Marine Fisheries Service's (NMFS) determination under limit 6 of the ESA 4(d) rules for Puget Sound Chinook salmon and Puget Sound steelhead (50 CFR § 223.203(b)(6)) concerning the Tulalip Tribes and the Washington Department of Fish and Wildlife (WDFW) hatchery programs in the Snohomish River basin; and, (2) the Bureau of Indian Affairs' (BIA) ongoing disbursement of funds for operation and maintenance of the Tulalip tribal hatchery programs listed in Table 1. Collectively, NMFS and the BIA are the "Action Agencies." Pursuant to the letter received by NMFS from the BIA, NMFS is the designated lead agency for the conduct of this consultation (Speaks 2013).

The Tulalip Tribes and WDFW propose to operate six hatchery programs that release Chinook, coho and fall chum salmon into the Snohomish River basin (Table 1). As described in section 1.8 of the Hatchery and Genetics Management Plans (HGMP) (Tulalip 2012; 2013a; 2013b; WDFW 2013a; 2013b; 2013c), all of the hatchery programs are operated for fisheries harvest augmentation purposes.

Chinook salmon propagated through these hatchery programs are included as part of the ESA-listed Puget Sound Chinook salmon Evolutionarily Significant Unit (ESU). "Hatchery programs with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU are considered part of the ESU and will be included in any listing of the ESU" (NMFS 2005c). For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or Distinct Population Segment (DPS), see Section 2.4.1 (NMFS 2005c). NMFS considers the Chinook salmon from these hatchery programs to be integrated[1] because they are derived from the ESA-listed natural Skykomish River ("Skykomish") population that is native to the Snohomish River basin, contain genetic resources that represent the ecological and genetic diversity of the Skykomish Chinook salmon population, and because the hatchery programs collect natural origin fish for hatchery broodstock.

Coho and fall chum salmon in Puget Sound, including the coho and fall chum salmon from the hatchery programs considered in this opinion, are not listed under the ESA. NMFS considers the coho salmon from the hatchery programs to be integrated[1] with the natural populations of coho salmon in the Snohomish Basin because they are derived from stocks native to the Snohomish River basin. The chum salmon from the hatchery program are not derived from the local natural population and are considered segregated/isolated[1]. Adult chum salmon produced by the program are not intended to spawn naturally and are not intended to establish, supplement, or support any chum salmon populations occurring in the natural environment.

[1] These terms are defined in Section 2.4.1.

Table 1. Hatchery programs associated with the Proposed Action, including program operator and funding agency.

Hatchery and Genetics Management Plan (HGMP)	Program Operator	Funding Agency
Bernie Kai-Kai Gobin Salmon Hatchery "Tulalip Hatchery" Subyearling Summer Chinook Salmon (Tulalip 2012)	Tulalip Tribes	BIA
Tulalip Bay Hatchery Coho Salmon (Tulalip 2013a)	Tulalip Tribes	BIA
Tulalip Bay Hatchery Chum Salmon (Tulalip 2013b)	Tulalip Tribes	BIA
Wallace River Hatchery Summer Chinook Salmon (WDFW 2013a)	WDFW	WDFW
Wallace River Hatchery Coho Salmon (with the Eagle Creek Hatchery cooperative program) (WDFW 2013b)	WDFW	WDFW
Everett Bay Net-Pen Coho Salmon (WDFW 2013c)	WDFW	WDFW

1.1 Background

The 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 seq.), and implementing regulations at 50 CFR 402. The opinion documents consultation on the actions proposed by NMFS and the BIA.

The NMFS also completed an Essential Fish Habitat (EFH) consultation. It was 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 at 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. The project files for these consultations are held at the Sustainable Fisheries Division (SFD) of NMFS in Lacey, Washington.

1.2 Consultation History

There has been a learning curve and resulting evolution in how to approach and conduct hatchery consultations in Puget Sound since the ESA-listing of the Puget Sound Chinook salmon ESU (64 FR 14308, March 24, 1999). Initially, the goal was to collect all the HGMPs proposed for implementation in Puget Sound by the Puget Sound Tribes and WDFW (hereafter, the "co-managers"), at that time, totaling 114 HGMPs region-wide, and bundle them into two Resource Management Plans (RMP) for ESA consultation purposes. To meet National Environmental Policy Act (NEPA) requirements associated with NMFS's 4(d) determinations on the two RMPs, a Draft Environmental Impact Statement (the "Puget Sound Hatcheries Draft EIS") was prepared to disclose the environmental effects of the proposed RMPs encompassing all Puget Sound region hatchery programs, and of alternative hatchery operation scenarios, including an alternative evaluating impacts if all hatchery programs were terminated (NMFS 2014a).

As the Puget Sound Hatcheries Draft EIS was being prepared, the co-managers continued to update and make important changes in their hatchery operations, leading to revisions in the HGMPs originally submitted to NMFS. The revised HGMPs were then submitted in updated form for NMFS's consideration, supplanting the HGMPs and RMPs reviewed in the completed Puget Sound Hatcheries Draft EIS.

After reviewing the pros and cons of analyzing all Puget Sound region HGMPs proposed by the co-managers in a single document, and considering public comments that NMFS received on the Puget Sound Hatcheries Draft EIS, NMFS decided to withdraw the Draft EIS (80 FR 15986, March 26, 2015). The process to review all Puget Sound region HGMPs through a single process was replaced with an approach whereby NEPA and ESA review to evaluate effects of the updated, resubmitted HGMPs would be conducted in bundles generally organized on a watershed basis. The HGMP bundles, and the current statuses of ESA and NEPA review processes for each, are described in Appendix Table 1. Under this watershed-scale approach, NMFS will evaluate the effects of hatchery programs that are unique to each watershed, including whether the programs address ESA 4(d) rule criteria for hatchery actions. Although the document has been withdrawn, relevant information and analysis included in Puget Sound Hatcheries Draft EIS, along with public comments received on the document, will continue to be considered by NMFS in subsequent NEPA reviews of the watershed-specific HGMPs.

Among the Puget Sound region HGMPs that have been submitted for NMFS consideration under the ESA are six plans developed by the Tulalip Tribes and WDFW describing hatchery programs for Chinook salmon, coho salmon, and fall chum salmon in the Snohomish Basin. On December 20, 2012, NMFS received one HGMP for the Tulalip Tribal hatchery Chinook salmon program on Tulalip Creek, a tributary to Tulalip Bay, with a request to process the HGMP under limit 6 of the 4(d) rule as a joint co-manager plan (Tulalip 2012). The Tulalip Tribes subsequently submitted two additional HGMPs for review under 4(d) rule, limit 6 on June 20, 2013, describing programs for coho salmon and fall chum salmon that would release juvenile fish into Tulalip Bay (Tulalip 2013a; 2013b). On February 19, 2013, NMFS received an HGMP for the WDFW Chinook salmon hatchery program at Wallace River Hatchery, with a cover letter requesting review of the plan under limit 6 (WDFW 2013a). On June 27, 2013, NMFS received WDFW's HGMP for the Everett Bay Net-pen coho program (WDFW 2013c), and on October 14, 2013, WDFW's HGMP for the Wallace River Hatchery coho salmon program (WDFW 2013b) was received. The Wallace River Hatchery coho salmon HGMP was revised and resubmitted on September 19, 2016. Both of the WDFW coho salmon HGMPs were also submitted for NMFS review under 4(d) rule limit 6. This biological opinion is based on information provided in these HGMPs.

On December 15, 2017, NMFS published in the Federal Register notification of the availability of its ESA 4(d) Rule proposed evaluation and pending determination (PEPD) for the six joint salmon HGMPs for public review and comment (81 FR 90784). A draft Environmental Assessment (EA), assembled by NMFS to evaluate compliance of any NMFS ESA 4(d) Rule determination regarding the HGMPs with the NEPA, was made available for public review at the same time, as announced in the same notice. During the public review period, NMFS received comments from one commenter – WDFW. WDFW's substantive comments applicable to Snohomish River basin salmon hatchery actions and effects were reviewed and considered in this opinion.

1.3 Proposed Action

"Action" means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. NMFS has not identified any interrelated and interdependent actions for this analysis.

The Proposed Actions are: (1) NMFS' determination under limit 6 of the ESA 4(d) rules for listed Puget Sound Chinook salmon and listed Puget Sound steelhead (50 CFR § 223.203(b)(6)) concerning the Tulalip Tribes and the WDFW hatchery salmon programs in the Snohomish River basin; and, (2) the BIA's ongoing disbursement of funds for operation and maintenance of the three Tulalip tribal hatchery salmon programs listed in Table 1.

The act of funding various hatchery activities does not have an immediate direct effect on listed salmonids. However, there are indirect effects on listed salmonids from the various funding decisions that manifest through the proposed tribal and WDFW hatchery operations. NMFS finds that the indirect effects of Federal funding are coextensive with the proposed implementation of the HGMPs. The indirect effects from funding are evaluated and considered below in the context of NMFS' overall determination under Limit 6 of the ESA 4(d) rule (50 CFR § 223.203(b)(6)).

NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008c). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004). In this specific case, the proposed hatchery salmon programs described in the Tulalip Tribes (Tulalip 2012; 2013a; 2013b) and WDFW (WDFW 2013a; 2013b; 2013c) HGMPs were determined sufficient for formal consultation (Jones 2013). Two of the hatchery programs release ESA-listed Chinook salmon, and four hatchery programs release non-ESA listed coho and fall chum salmon into, or in the immediate vicinity of, the Snohomish River basin. All of the programs are currently operating. The Chinook and coho salmon hatchery programs raise fish native to the Snohomish River basin. The fall chum salmon propagated at Tulalip Bay were transferred from Hood Canal and Deep South Sound (Tulalip 2013b).

The primary purpose for these hatchery programs is to help meet adult fish loss mitigation responsibilities, partially off-setting adverse impacts to natural-origin salmon abundances that historically sustained tribal and State fisheries. In meeting this purpose, the hatchery programs would be implemented applying actions designed to minimize risks of adverse effects on listed fish species. Key premises of the programs are that habitat that once sustained abundant natural salmon populations has been degraded by past and on-going human developmental activities in the Snohomish River basin, and natural salmon and their habitat are furthered threatened by climate change. The goals for the programs are therefore, lacking natural salmon in abundance, to provide Chinook, coho and chum salmon for harvest to support regional fisheries, provide values associated with Treaty-reserved fishing rights recognized by the Federal courts, and help to meet Pacific Salmon Treaty harvest sharing agreements with Canada (Tulalip 2012; WDFW 2013a). All of the programs would implement salmon population monitoring activities in marine and freshwater areas that are important for tracking the status of ESA-listed fish populations and the effects of the hatchery programs.

The fishing seasons and regulations developed specifically to harvest salmon produced by the programs have previously been reviewed under the ESA, and NMFS's authorization for 'take' from fisheries is part of an already completed consultation (NMFS 2015a). The co-managers propose fishery management plans for Puget Sound and associated freshwater on either an annual or multi-year basis, and NMFS generally consults on these plans and addresses the take effects of Snohomish River basin salmon-directed recreational and commercial fisheries through an ESA section 7 consultation for the duration of the relevant plan. Most recently, NMFS issued a biological opinion (NMFS 2017b) for a 2017 Puget Sound harvest plan assembled by the co-managers that found that the harvest plan for 2017 fisheries did not jeopardize ESA-listed species. The harvest plans submitted by the co-managers have remained relatively similar over the past several years and are expected to continue to do so in 2017 and beyond.

1.3.1 Describing the Proposed Action

Activities included in the plans are as follows:

- Broodstock collection at WDFW's Wallace River Hatchery (Wallace River and May Creek weirs); Sunset Falls Fishway; and the Tulalip Tribes' lower Tulalip Creek hatchery pond and Battle Creek (local name, official USGS name is Mission Creek) spawning station through operation of weirs and fish traps;
- Transport of adult Chinook and coho salmon from the Sunset Falls Fishway to Wallace River Hatchery;
- Holding, identification, biological sampling, and spawning of adult fish at Wallace River Hatchery, the lower Tulalip Creek pond, and the Battle Creek spawning station;
- Egg incubation and/or fish rearing at Wallace River Hatchery, Bernie Kai-Kai Gobin Tulalip Tribal Salmon Hatchery (hereafter, Tulalip Hatchery), Tulalip Creek ponds, Battle Creek pond, Eagle Creek Hatchery, and Everett Bay Net Pens;
- Release of up to: 1.0 million subyearling and 500,000 yearling Chinook salmon from Wallace River Hatchery; 2.4 million subyearling Chinook salmon from Tulalip Hatchery; 150,000 coho salmon from Wallace River Hatchery; 2.0 million coho salmon from the Tulalip Creek Hatchery ponds; 12.0 million fall chum salmon from the Battle Creek pond; 54,000 coho salmon from Eagle Creek Hatchery, and 20,000 coho salmon from the Everett Bay Net-Pen site;
- Release into the Wallace River of adult natural-origin and/or hatchery-origin Chinook salmon surplus to hatchery broodstock needs at Wallace River Hatchery; and
- Monitoring and evaluation to assess the performance of the programs in meeting harvest augmentation and listed fish risk minimization objectives.

These activities are described in greater detail below. Several only pose effects to ESA-listed Chinook salmon in the Snohomish Basin, so are only described with respect to this species.

1.3.1.1 *Proposed hatchery broodstock collection*

- Broodstock origin and number:
    - Chinook salmon: Up to 3,200 adult Chinook salmon of native Skykomish natural- and hatchery-origin stock would be collected at Wallace River Hatchery, by seining the area immediately below the Wallace River hatchery weirs, and from the Sunset Falls Fishway (South Fork Skykomish River at river mile [RM] 51.5) for use as broodstock each year to sustain the Wallace River and Tulalip hatchery programs. When broodstock shortfalls occur at the Wallace River Hatchery, Chinook salmon may be collected from adult returns to Tulalip Bay at the lower Tulalip Creek pond. Adult returns after September 30th are excluded from collections to reduce the risk of including remnant introduced Green River-lineage fall Chinook salmon adults in the broodstock (see Tulalip 2012 for a description of the legacy fall Chinook salmon hatchery program). The exception to this rule is that post October 1st adults returning to Wallace River Hatchery may be used to fulfill egg take needs for the Tulalip Hatchery program in years when there are short-falls in collections of required earlier spawning Skykomish stock.
    - Coho salmon: Up to 4,638 adults of Skykomish River stock returning to Wallace River Hatchery would be required to sustain the three programs for the species in the Snohomish River basin. This number of adult coho would also supply eggs to sustain the Squaxin Island and South Sound Net-Pen programs and educational cooperative ventures that are not part of the proposed actions considered in this consultation (WDFW 2013b). Broodstock collected to sustain the Wallace River Hatchery and Everett Bay Net-pen programs would be integrated with 500 viable natural-origin coho salmon collected from returns to Wallace River Hatchery, and/or from transferred adults collected at the Sunset Falls Fishway.
    - Chum salmon: Up to 9,000 adults of localized, Hood Canal/Deep South Sound lineage stock-origin returning to Battle Creek, a tributary to Tulalip Bay, would be collected and spawned each year to sustain the tribal chum salmon hatchery program. The adult fish collection levels proposed to meet egg take needs apply existing data for pre-spawning adult mortality rates, sex ratios, and average fecundities observed at the hatcheries in past years for each species.
- Proportion of natural-origin fish in the broodstock (pNOB) (Chinook salmon only): Natural-origin Chinook salmon collected at Wallace River Hatchery traps, in the Wallace River, and at the Sunset Falls Fishway are incorporated as broodstock for the Wallace River Hatchery program. Of the 3,200 Chinook salmon collected to sustain juvenile fish production for the Wallace River and Tulalip hatchery programs each year, 880 fish will be spawned for the Wallace River Hatchery integrated program. For the Wallace River Hatchery program, accounting for holding mortality (an average of 25.7% of the total number of natural-origin Chinook salmon collected each year die before spawning - M. Crewson, pers. comm., October 14, 2014), up to 400 natural-origin fish may be collected to attain the target integration level of 300 natural-origin fish of the total 880 hatchery and natural-origin fish Wallace River Hatchery broodstock objective. Of the 400 natural-origin Chinook salmon broodstock collected for holding through spawning, up to 225 fish would be collected at the Sunset Falls Fishway, with the remainder collected from returns to the Wallace River (Tulalip 2012; WDFW 2013a). Fewer natural-origin fish will be collected for broodstock under certain conditions. During the course of broodstock collection at Wallace River Hatchery, in the Wallace River, and at Sunset Falls

Fishway, up to 1,912 natural-origin Chinook salmon above the number needed for broodstock may be captured, handled, and released (WDFW 2013a). Of this total, capture, handling and release effects for the 1,000 natural-origin Chinook salmon encountered during operation of the Sunset Falls Fishway program were previously authorized through a separate ESA consultation (NMFS 2009). The co-managers would apply annual limits on the number of natural-origin Chinook salmon trapped from returns to the Wallace River weir and held at Wallace River Hatchery for spawning, with preference given to use of natural-origin fish to meet natural-spawning escapement objectives in the Wallace River when integration goals are met at the hatchery. Also applied would be a limit of 400 fish or 20% of the total natural Chinook salmon adult return (whichever is lower) on the proportion of the total annual natural-origin Chinook salmon escapement to the Sunset Falls Fishway that can be removed for use as broodstock. Additionally, removal of natural-origin fish at Sunset Falls must not allow the natural-origin escapement in the basin (exclusive of the Wallace River) to drop below 1,745 fish, which is the Low Abundance Threshold (LAT) for the Skykomish Chinook salmon population (PSIT and WDFW 2010). These limits would be applied to ensure that adequate numbers of natural-origin Skykomish Chinook salmon escape to spawn naturally. No natural-origin fish will be collected for use as broodstock for the Tulalip Chinook salmon program, and all eggs provided for the program will be taken from adult returns to Wallace River Hatchery. In rare occasions, adults to sustain the tribal program will be collected from Tulalip Bay, where returns are predominantly first generation hatchery-origin fish.

- Broodstock selection: To reduce the risk of hatchery-influenced selection and loss of within-population diversity for all cultured salmon species, annual adult broodstock collection activities would occur across the breadth of the summer, fall, and early winter periods when adult Chinook, coho, and fall chum salmon return to the Basin (July through December). Measures would be applied to help ensure that salmon collected as broodstock would be representative of the run-at-large adult returns. The Sunset Falls Fishway component of the Chinook and coho salmon broodstock collection efforts would be implemented specifically for the purpose of selecting natural-origin Skykomish River adults for spawning.
- Method and location for collecting broodstock: Wallace River Hatchery, located at the confluence of May Creek and the Wallace River (RM 4.0), operates two adult collection weirs, one on each stream. Chinook and coho salmon broodstock needed for production at the WDFW and Tulalip Tribal facilities would be collected as volunteers returning to the two weirs at the WDFW hatchery, and adult fish returning to the Sunset Falls Fishway. Chinook salmon broodstock may also be collected in a ladder and trap from returns to lower Tulalip Creek, as a contingency to augment broodstock collection shortfalls at Wallace River Hatchery. Chinook salmon adults collected at the Sunset Falls Fishway would be transferred by truck for holding and spawning at Wallace River Hatchery. In years when adults do not volunteer to the WDFW traps at required broodstock collection levels, hatchery-origin (only) Chinook salmon may be collected for broodstock by seining, restricted to the area immediately below the Wallace River weir. When in place to collect broodstock (early June through October 1st), the Wallace River weir blocks upstream migration for adult Chinook and coho salmon returning to the river. The hatchery weir on May Creek is not an impediment to any naturally spawning Chinook salmon aggregation. Adult Chinook salmon collected at Wallace River Hatchery that are surplus to the combined egg-take goal for Wallace River and Tulalip hatchery programs would be released into the Wallace River to help meet co-manager-established "Minimum Spawner Guidelines" (MSG)

of 303 male and 202 female natural spawners in the lower Wallace River, and 224 and 149 males and females in the upper river.

- Coho salmon broodstock required to meet smolt production needs for the three hatchery programs propagating the species would be collected predominantly at Wallace River Hatchery. Natural-origin coho salmon collected at the Sunset Falls Fishway would be transferred to Wallace River Hatchery for spawning as needed to meet the annual goal for natural-origin coho salmon integration of 500 adult fish. In years when Chinook and coho salmon broodstock shortages are projected at Wallace River Hatchery, adult fish may be collected from returns to Tulalip Bay to augment annual egg takes. The tribe intends to meet broodstock collection needs for its fall chum salmon program through operation of weirs and traps to procure adults returning to Battle Creek.
- Duration of collection: To collect Chinook and coho salmon broodstock, the May Creek weir at Wallace River Hatchery would be operated from June through November each year, and the Wallace River weir would be operated from June through October annually. Natural-origin adult Chinook and coho salmon may be collected at the Sunset Falls fishway for transport to Wallace River Hatchery from June through October each year. Fall chum salmon would be collected annually from adult returns to Battle Creek from November to January.
- Encounters, sorting and handling, with ESA listed fish, adults and juveniles: Between 2006 and 2013, the annual total number of natural-origin Chinook salmon adults collected for use as hatchery broodstock ranged from 117 to 450 fish and averaged 302 fish. Regarding the annual number of fish handled, based on observed Chinook salmon returns from 2006 through 2013, up to 912 ESA-listed natural-origin Chinook salmon not needed as broodstock may be encountered each year in the course of Chinook and coho salmon broodstock collection activities at Wallace River Hatchery, in the Wallace River, at Tulalip Bay Hatchery. The number of natural-origin Chinook retained and held for spawning at the Wallace River Hatchery will not exceed 400 Chinook salmon; all Chinook salmon trapped in excess of broodstock needs will be released into natural spawning and migration areas. Small numbers of ESA-listed steelhead are encountered at the Wallace River weir during the late fall, and, based on recent year observations, less than six ESA-listed steelhead may be captured, handled, and immediately released each year. Measures are applied to limit the risk of adverse capture, handling, and release effects on steelhead through application of appropriate protocols described in the HGMPs (WDFW 2013a; 2013b). There are no ESA-listed salmonids in Battle Creek, and there would therefore be no encounters, and incidental capture and handling effects, on ESA-listed Chinook salmon and steelhead associated with adult chum salmon hatchery broodstock collection.

Annual adult Chinook and coho salmon escapement monitoring in the Snohomish River watershed to gauge hatchery program performance and effects (stream surveys and biological sampling) may also lead to encounters (takes) of ESA-listed Chinook salmon. Effects would potentially include harassment (disturbance) of naturally spawning fish during the course of spawning ground surveys and biological sampling of carcasses.

1.3.1.2 Proposed mating protocols (listed Chinook salmon only)

- Chinook salmon used for broodstock for on-station releases at Wallace River Hatchery would be selected randomly as the fish mature, and representatively across the maturation period for the summer Chinook salmon broodstock population (WDFW 2013a, and following). All available (up to 400) unmarked (assumed to by natural-origin) Chinook salmon returning before October 1st would be spawned for the Wallace River on-station release program. Broodstock for which progeny would be designated for transfer to Tulalip Hatchery would be selected randomly from known (marked) hatchery-origin fish returning to Wallace River Hatchery. In years when there were short-falls in the number of broodstock returning prior to October 1st, late-returning (post October 1st) fish would be collected to augment egg takes up to the annual egg collection objective. Any post-October 1st egg takes would only be used for the Tulalip Bay Hatchery release program. Hatchery-origin Chinook salmon broodstock would be spawned as the fish mature across the entire maturation period for the population retained for spawning. The proportion of ripe fish encountered (of the total estimated to be available for spawning) would be factored against the total egg-take goal to determine the daily egg-take schedules so that the gametes collected over the spawning period represent maturation timing for the population. All male Chinook salmon collected, including jacks, would be considered for spawning. Males would be chosen randomly from the held population, and jacks would be incorporated into spawning at a rate of 2% of spawned males. Eggs pooled from five females would be equally divided into five buckets and the eggs in each bucket fertilized with milt from one male (matrix spawning). After 60 seconds of fertilization time, all eggs would then be combined into one bucket. The eggs would then be placed in vertical incubator trays and water-hardened for 1 hour in an iodophor solution of 100 ppm.

1.3.1.3 Proposed protocols for each release group

- Life stage: Chinook salmon: Subyearlings from Wallace River Hatchery at 70 fish per pound (fpp) (83 mm fork length [fl]) and yearlings at 10 fpp (155 mm fl). Subyearlings from Tulalip Hatchery at 80 fpp (80 mm fl). Coho salmon: Wallace River Hatchery yearlings at 17 fpp (131 mm fl); Tulalip Hatchery yearlings at 16 - 18 fpp (~140 mm fl); Eagle Creek Hatchery yearlings at 15 fpp (162 mm fl); Everett Bay Net-Pens delayed release yearlings at 15 fpp (150 mm fl). Fall chum salmon: Tulalip Hatchery Fry at 400-550 fpp (50 mm – 60 mm fl).
- Acclimation (Y/N): Yes. Chinook and coho salmon would be acclimated prior to release at Wallace River Hatchery and the Tulalip Hatchery complex; Coho salmon would be acclimated prior to release at Eagle Creek Hatchery and the Everett Bay Net-Pens; and fall chum salmon would be acclimated prior to release at the Tulalip Tribes' Battle Creek Pond.
- Volitional release (Y/N): Chinook salmon: Wallace River Hatchery – Yes - volitional, then forced; Tulalip Hatchery: No – forced. Coho salmon yearlings: Wallace River Hatchery - Yes - volitional, then forced; Tulalip Hatchery – Yes; Eagle Creek Hatchery: No - forced; Everett Bay Net-Pens – No – forced. Fall chum salmon: Yes – volitional at Battle Creek, then forced.
- External and/or internal mark(s): All juvenile fish released through the programs would be marked, tagged, and/or fin clipped to allow for their differentiation from natural-origin salmon

after their release as juveniles from the hatcheries, and when the fish return as adults to Snohomish River basin marine and freshwater areas.

- Chinook salmon: Table 2 summarizes marking and/or tagging strategies applied to Chinook salmon produced by the two hatchery release programs. All juveniles released would be thermally otolith-marked to allow for their identification after release by hatchery and brood year of origin. The majority of subyearling Chinook salmon from both programs would also receive adipose fin clips only, while smaller groups would receive adipose fin clips and coded wire tags (CWTs) (200,000 at Wallace River Hatchery and 100,000 at Tulalip Hatchery), or CWTs only as part of double-index tagging (DIT) groups (200,000 at Wallace River Hatchery and 100,000 at Tulalip Hatchery). All yearling Chinook salmon released from Wallace River Hatchery would be adipose fin-clipped and otolith-marked, while a portion (~80,000) would also receive CWTs, predicated on funding availability.

Table 2. Hatchery-origin Chinook salmon marking and/or tagging strategies applied to fish produced by the Wallace River hatchery and Tulalip Bay Hatchery programs.

Program and group	Total	Otolith		External/Internal Mark Break-Out of Total		
				Ad-Clip-Only	CWT-Only	Ad-Clip+CWT
Wallace/1+	500,000	500,000		420,000*	-	80,000*
Wallace/0+	1,000,000	1,000,000		600,000	200,000	200,000
Tulalip/0+	2,400,000	2,400,000		2,200,000	100,000	100,000

*Although the intention is to apply an "AD-Clip+CWT" tag/mark to 80,000 yearlings each year, doing so is contingent on the availability of funding. Elimination of this strategy would increase the annual "Ad-Clip Only" number of yearlings released to 500,000.

- Coho salmon: All production at both hatcheries would be adipose fin-marked and and/or CWT to allow for their differentiation from natural-origin salmon after their release from the hatcheries and when the fish return as adults to Snohomish River basin marine and freshwater areas. All coho salmon released from Wallace River Hatchery would receive an adipose fin clip only, an adipose fin clip/CWT combination (~45,000), or CWT only (~45,000). All yearling coho salmon released into Tulalip Bay through the Tulalip pond program would be marked with an adipose fin clip, with ~45,000 also receiving CWTs. All Eagle Creek Hatchery and Everett Bay Net-Pen coho salmon would be marked with an adipose fin clip.

- Chum salmon: All fry released through the Battle Creek Pond program would receive a thermally-induced otolith mark. Annual mark recovery programs in U.S. and Canadian marine and freshwater fishing areas, in natural spawning areas, and at hatcheries would be used to identify, to the extent feasible, hatchery-origin fish originating from the program. These hatchery-origin fish recovery data would be used to estimate total fisheries contribution and escapement for Snohomish River basin hatchery salmon production.

- Maximum number released: Wallace River Hatchery: 1.0 million subyearling Chinook salmon, 500,000 yearling Chinook salmon, and 150,000 yearling coho salmon; Tulalip Hatchery: 2.4 million subyearling Chinook salmon, 2.0 million coho salmon yearlings, and 12.0 million fall chum salmon fry; Eagle Creek Hatchery: 54,000 coho salmon yearlings; Everett Bay Net-Pen: 20,000 delayed release yearling coho salmon.
- Release location(s): Wallace River Hatchery Chinook and coho salmon: river mile 4.0 Wallace River, entering the Skykomish River at RM 35.7. Tulalip Hatchery Chinook and coho salmon: Tulalip Creek Upper and Lower Ponds, RM 0.1 on Tulalip Creek, tributary to Tulalip Bay. Tulalip Hatchery fall chum salmon: Battle Creek Pond, RM 0.1 on Battle Creek, tributary to Tulalip Bay. Eagle Creek Hatchery coho salmon: RM 0.4 on Eagle Creek, tributary to the Skykomish River at RM 28.3. Everett Bay Net-Pen coho salmon: mouth of the Snohomish River at Port Gardner Bay, Port of Everett Marina.
- Time of release: Chinook salmon: subyearlings in May - June; yearlings in April. Coho salmon: yearlings in May-June. Chum salmon fed fry: April – mid-May.
- Fish health certification: Reporting and control of specific fish pathogens will be conducted in accordance with the "The Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State" (NWIFC and WDFW 2008).

1.3.1.4 Proposed adult management (listed Chinook salmon focus)

- Anticipated number or range in hatchery fish returns originating from this program: For a smolt to adult return rate of 0.46% for Chinook salmon subyearlings (Tulalip SAR – Tulalip 2012) and 1.42% for yearlings (Tulalip 2012), the proposed Wallace River Hatchery and Tulalip Hatchery programs may produce 22,740 adults each year (total contribution to all fisheries and escapement). The majority of Chinook salmon adults recruit back to their hatchery release locations (CWT recovery data from WDFW 2013a), but escapement to natural spawning areas in the Snohomish River basin does occur. The average hatchery-origin Chinook salmon proportions of the total naturally spawning Skykomish and Snoqualmie Chinook populations (i.e., pHOS) for the most recent six years for which population census data are available (2009-2014) were 28.8%, and 22.6%, respectively (Tulalip 2012; Tulalip Tribes, unpublished data). The basin-wide annual average pHOS for 2006-2014 was 25.5%.
- Removal of hatchery-origin fish and the anticipated number of natural-origin fish encountered: A substantial proportion – 35% to 40% - of hatchery-origin Chinook salmon produced by the Wallace River Hatchery program would be harvested in Canadian and U.S. pre-terminal and Puget Sound terminal area fisheries (WDFW 2013a). The majority of remaining adult fish escape to Wallace River Hatchery – approximately 60% of subyearling-origin adults and 65% of yearling adults (CWT recovery data in WDFW 2013a). Fishery harvest rates on hatchery Chinook salmon returning to the Tulalip Hatchery release site would be managed to be as close to 100% as possible through implementation of targeted terminal area fisheries in Tulalip Bay, where hatchery-origin adult returns concentrate. No Chinook salmon would generally be reserved in Tulalip Bay for broodstock collection, allowing for harvest (and removal rates) for hatchery fish to be maximized. The effects of these fisheries on ESA-listed natural-origin Chinook salmon were evaluated and authorized through a separate ESA consultation (NMFS 2015a). Annual Chinook salmon broodstock collection will lead to the collection and successful spawning of up to 2,900 hatchery-origin adults and up to 300 natural-origin adults. Up to 2,212

natural-origin adults may be incidentally encountered at Wallace River Hatchery, in the Wallace River, and at the Sunset Falls Fishway, and 400 natural-origin adults may be removed as a result of proposed broodstock collection and adult fish holding actions.

- Appropriate uses for hatchery fish that are removed: Chinook, coho, and fall chum salmon escaping to the hatcheries would be sold to fish buyers, distributed to tribal members for food, donated to food banks, or distributed within the Snohomish River basin for marine-derived nutrient enhancement purposes.
- Are hatchery fish intended to spawn naturally (Y/N): No. The donor broodstock for the Chinook and coho salmon hatchery programs are the Skykomish Chinook and coho salmon populations. Although the Chinook salmon at these hatchery programs are of native stock, the hatchery fish are produced for harvest augmentation purposes and are not intended to augment natural spawning by the species. Fall chum salmon produced by the Battle Creek program are an out-of-basin transplanted stock, with harvests intended to maximize removal of returning adults, and limited only to meet hatchery escapement needs.
- Performance standard for pHOS (proportion of naturally spawning fish that are of hatchery-origin): The operators are exploring estimates of gene flow based on genetic rather than demographic measures (see discussion in Section 2.4.2.2 of the implications of this approach). As a result, in the HGMPs they make a distinction between demographically and genetically based estimates of pHOS, pNOB, and PNI by appending D and G subscripts, respectively, as appropriate. For consistency, we follow that convention in this document when necessary; when presented without subscripts, pNOB, pHOS, and PNI denote measures based on demographic data. As an interim measure for hatchery Chinook salmon management, before gene flow-based data are available (as described in Tulalip 2012, and see Section 1.3.1.5 below), demographic (carcass recovery based) methods will be applied. The demographic ratio of estimated numbers of artificially-produced Chinook salmon to the total spawning escapement ($pHOS_D$), derived based on carcass counts identified by origin through spawning ground surveys, is monitored with the objective of limiting $pHOS_D$ for the integrated Skykomish population to under 30%. This level is based on modeling that indicated that controlling $pHOS_D$ to 30 to 50% in the Wallace River where the WDFW hatchery is located would result in an estimated pHOS of under 30%, and a PNI_D estimate of >0.5 for the entire Skykomish population.
- Performance standard for stray rates into natural spawning areas: The projected stray rates of total adult returns for Tulalip Hatchery Chinook salmon into natural population spawning areas are 0.5% of total escapement for the Skykomish population and 1.4% for the Snoqualmie population (Tulalip 2012).

1.3.1.5 Proposed research, monitoring, and evaluation

- Adult sampling, purpose, methodology, location, and the number of ESA-listed fish handled: The six HGMPs include monitoring and evaluation (M&E) actions designed to identify the performance of the programs in meeting their fisheries harvest augmentation and listed fish risk minimization objectives. Specific M&E actions for the six HGMPs affecting adult salmon are described in section 1.10 and section 11.0 of each HGMP, and in section 12.0 of the Tulalip Hatchery Chinook salmon HGMP (Tulalip 2012). Although monitoring the harvest benefits of the programs to fisheries from production of returning adult hatchery-origin fish is an important objective (e.g., smolt to adult survival rate and fishery contribution level monitoring), all of the Snohomish River basin hatchery programs include extensive monitoring, evaluation, and adaptive management measures, designed to monitor and reduce incidental effects on natural-origin fish populations. An adult Chinook salmon monitoring program (stream surveys and biological sampling) would be conducted annually to document HOR/NOR ratios, spawning contribution and straying rates, and develop estimates of gene flow and relative effective abundance, productivity (calculated from genetic and demographic data), spatial structure, diversity, age, sex, and size of natural- and hatchery-origin Chinook escaping to natural spawning areas and the hatcheries in the Snohomish River basin. The co-managers will use this information to verify compliance with proposed HGMP actions, and to inform and advise adaptive management of hatchery actions to meet HGMP performance criteria. Specific actions described in the HGMPs would include monitoring of Chinook salmon escapement to Snohomish River basin natural spawning areas to estimate the number of clipped, tagged, and thermally-marked fish escaping to Snohomish River basin tributaries each year. Foot and boat spawning ground surveys would be implemented to count spawning fish and sample Chinook salmon carcasses for scales, otoliths, adipose-fin clips, CWT's, and tissues for genetic analysis. The same level and types of biological sampling would be implemented for fish escaping to the hatcheries and collected as broodstock. The Terms and Conditions of this Biological Opinion require the completion and distribution of annual reports describing adult salmon M&E activities and results.

- Juvenile sampling, purpose, methodology, location, and the number of ESA-listed fish handled: Specific M&E actions for the six HGMPs affecting juvenile salmon are described in section 1.10 and section 11.0 of each HGMP, and in section 12.0 of the Tulalip Hatchery Chinook salmon HGMP (Tulalip 2012). Although the results of these juvenile fish M&E actions would be used to guide implementation of the proposed salmon hatchery programs, juvenile salmon sampling occurring outside of the hatchery locations have been previously authorized through a separate ESA consultation process (NMFS 2017a). The co-managers propose to continue to monitor interactions between juvenile hatchery- and natural-origin salmon in freshwater and marine areas within the region to evaluate and manage program ecological effects. Continued juvenile outmigrant trapping by the Tulalip Tribes is also proposed, using rotary screw or inclined plane traps in the Skykomish and Snoqualmie systems and seines in estuarine and nearshore marine areas, to provide important information on the co-occurrence, out-migration timing, relative abundances and relative sizes of hatchery-origin fish, ESA-listed natural-origin Chinook salmon and steelhead, and non-listed natural-origin coho, chum, and pink salmon.

- The Tulalip Tribes and WDFW’s Wild Salmon Production and Evaluation Unit would continue to conduct genetic mark recapture studies in the Snohomish Basin to evaluate the relative contribution of hatchery-origin Chinook salmon to natural production, and estimate escapement based on the number of effective breeders from genetic data. The genetic mark recapture research was previously authorized by NMFS for effects on ESA listed fish (NMFS 2017a; NMFS 2015b). Augmenting sampling, genotyping, and analysis results already completed (12,169 juvenile fish and 604 adult fish - Spidle 2017), these studies would continue, as funded through annual requests proposed through the Pacific Coast Salmon Restoration Fund (PCSRF) project review process. Through the studies, tissues collected from Chinook salmon smolts from the Tulalip Tribes' Skykomish and Snoqualmie traps, and tissues collected from adult fish on the spawning grounds, would be analyzed to determine contributions to natural production by fish origin and parentage.

- Up to 32,000 hatchery-origin adipose fin clipped subyearling Chinook salmon would be retained from the hatcheries each year for conducting juvenile outmigrant trap efficiency trials.

- The HGMPs include the completion and distribution of an annual report describing juvenile salmon M&E activities and results.

1.3.1.6 Proposed operation, maintenance, and construction of hatchery facilities

- Water source(s) and quantity for hatchery facilities: Six hatchery facilities are currently used by the proposed Snohomish River basin salmon hatchery salmon programs. Four of the facilities use surface water exclusively (Wallace River Hatchery; Tulalip Creek Ponds, Battle Creek Pond, and Eagle Creek Hatchery); one facility uses a combination of groundwater and surface water (Tulalip Hatchery); and one facility relies on passive tidal flow of marine water for fish rearing (Everett Bay Net-Pen). Up to 27 cfs from the Wallace River and 13 cfs from May Creek may be temporarily diverted into Wallace River Hatchery to support WDFW's Chinook and coho salmon hatchery programs. From 4.5 cfs to 16 cfs of surface water in the East Fork and West Fork of Tulalip Creek is impounded for use in fish rearing for the Tulalip Hatchery and from 5.2 to 41 cfs is impounded from Tulalip Creek for the Tulalip Creek Ponds program. From 2.2 to 15 cfs in Battle Creek is impounded for rearing chum salmon fry through the Tulalip Tribes' Battle Creek Pond program. Eagle Creek Hatchery relies on spring water for fish rearing, with withdrawal levels ranging from 0.7 to 0.9 cfs. The Everett Bay Net-Pen program uses seawater, passively supplied through tidal flow, for rearing coho salmon, and the amount coursing through the net-pen is not measurable relative to the total amount of water in the Puget Sound. All hatchery facilities have current surface water rights documented through permits issued by the Washington State Department of Ecology (e.g., WDFW 2013a). The wells at Tulalip Hatchery supplying groundwater to support the tribal summer Chinook and coho salmon programs are located on tribal Trust lands, and are therefore under the regulatory purview of the Tulalip Tribes regarding limits and permitted withdrawal levels. From zero to 1.6 cfs of groundwater would be withdrawn to support salmon production at Tulalip Creek Hatchery.
- Water diversions meet NMFS screen criteria (Y/N): No. WDFW plans to modify screening at Wallace River Hatchery to comply with NMFS screening requirements to protect natural-origin fish from entrainment and impingement that may lead to injury and mortality (WDFW 2013a). Although the hatchery water intake screens on the Wallace River and in May Creek are protective of fish and in compliance with state and federal guidelines (NMFS 1995, 1996), they do not meet updated NMFS Anadromous Salmonid Passage Facility Design Criteria (NMFS 2011c). However, under NMFS (2011c) criteria, screening currently in compliance with NMFS (1995) and NMFS (1996) guidelines are grandfathered in as acceptable, with the requirement that the screening be upgraded to meet the most recent NMFS standards when the next screen retrofit is scheduled. Design and permitting to bring the screens in compliance with NMFS (2011c) fish passage and screening criteria will begin in biennium 2015-2016, with construction in biennium 2017-2018 (WDFW 2013a), and project completion by fall 2020. This work will

also include construction of a new two-bay pollution abatement pond. Screening at the Tulalip Tribes' hatchery facilities and at Eagle Creek Hatchery are not risk factors as there are no ESA-listed fish populations present in the small tributaries where the facilities are located. NMFS screen criteria are not applicable for the Everett Bay Net-Pens program.

- Permanent or temporary barriers to juvenile or adult fish passage (Y/N): Yes. The hatchery weirs on Wallace River and May Creek, operated seasonally (June through October 1, and June through March, respectively) to collect Chinook and coho salmon broodstock, would be temporary barriers to upstream and downstream adult fish passage. Trapping protocols applied at the Wallace River weir would minimize the duration of migration delay and prospects for fish injury during trapping. Surplus adult Chinook salmon collected at Wallace River Hatchery and available after hatchery spawning requirements are met would be released into the Wallace River upstream of the hatchery weir to allow the fish to spawn naturally above RM 4.0. The impoundments used to rear fish in the Tulalip Creek watershed do not block upstream or downstream passage of any ESA-listed fish populations. Fish migration is not impeded by any structures used for fish rearing at Eagle Creek Hatchery and the Everett Bay Net-Pens.
- Instream structures (Y/N): Yes. The Wallace River Hatchery weir is located at RM 4.0 on the Wallace River. The May Creek trap located near the mouth of May Creek at its confluence with the Wallace River is another instream structure. According to the WDFW Chinook salmon HGMP (WDFW 2013a), the trap will eventually be replaced with a weir at the creek's mouth, subject to fish health considerations. The final rearing impoundments (ponds) used to rear, imprint, and release coho and fall chum salmon for the Tulalip hatchery programs are all instream structures. The water intake used for Eagle Creek Hatchery is a small instream structure.
- Streambank armoring or alterations (Y/N): No. There are no streambank armoring or alterations included as part of the proposed actions.
- Pollutant discharge and location(s): All hatchery facilities used by the Snohomish River basin salmon hatchery programs are operated in compliance with NPDES permits issued by WDOE or EPA, or do not require a NPDES permit. As authorized under NPDES Permit # WAG 13-3006, all hatchery effluent at Wallace River Hatchery is passed through a pollution abatement pond to settle out any uneaten food and fish waste before being discharged into receiving waters (WDFW 2013a). The Tulalip Tribes' salmon hatchery programs in the Tulalip and Battle creek watersheds are in compliance with NPDES permit requirements (Permit #s WAG-13- 0012, WAG -13-0013, and WAG -13-0014 - Tulalip 2012; 2013a; 2013b). The annual fish production levels for the Eagle Creek Hatchery and Everett Bay Net-Pen programs are below the level of concern for effluent discharge effects, and no discharge permit is required for their operation.

1.3.2 Interrelated and Interdependent Actions

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

Within the action area, recreational fisheries and tribal commercial and ceremonial and subsistence fisheries occur, targeting salmon produced by the proposed hatchery programs, and commingled natural-origin salmon that are surplus to spawning escapement needs. These fisheries are managed by the WDFW and Tulalip Tribes, and occur within the Snohomish, Skykomish, and Wallace River watersheds, as well as within Puget Sound terminal area marine waters of Tulalip Bay, Port Susan, and Everett Bay. The proposed hatchery salmon programs analyzed in this opinion also contribute regional fisheries outside of the Snohomish River watershed and marine terminal areas. Fisheries outside of the action area support values associated with Treaty-reserved fishing rights recognized by the Federal courts, support *U.S.* v. *Washington* (1974) harvest sharing agreements between tribal and non-Indian fisheries, and help to meet Pacific Salmon Treaty salmon harvest agreements with Canada. Outside of the Snohomish River basin action area, there are no directed fisheries for salmon produced by the six salmon hatchery programs. Those salmon-directed fisheries would occur regardless of whether the proposed action continues, and are therefore not interrelated or interdependent with the proposed action. Therefore, only those fisheries for salmon in the Snohomish River basin are interrelated and interdependent actions. The 2016-17 fisheries were evaluated and authorized through a separate NMFS ESA consultation (NMFS 2017). They were determined not likely to jeopardize the continued existence of the Puget Sound Chinook Salmon ESU, the Hood Canal summer chum salmon ESU, or the Puget Sound Steelhead DPS, or adversely modify designated critical habitat for these listed species (NMFS 2017). A new Puget Sound fishery management plan for 2017-18 is expected to be submitted for Section 7 consultation in spring 2017. Past effects of these fisheries are described in the environmental baseline section (Section 2.3); future effects are described in the discussion of effects of the action.

1.4 Action Area

The "action area" means all areas to be affected directly or indirectly by the Proposed Action, in which the effects of the action can be meaningfully detected measured, and evaluated (50 CFR 402.02). The action area resulting from this analysis includes the freshwater and estuarine areas within the Snohomish River basin, and tributaries and nearshore marine areas immediately adjacent to the basin where salmon originating from the proposed hatchery programs would migrate, potentially stray, and spawn naturally. The action area also includes areas where adult salmon from the programs would be collected as broodstock and artificially spawned, and where juvenile fish would be incubated, reared, acclimated, and released from the hatcheries (Figure 1).

The Snohomish River basin salmon hatchery programs would use the following facilities:

- Wallace River Hatchery (RM 4.0 on the Wallace River at its confluence with May Creek), entering the Skykomish River at RM 35.7
- Sunset Falls Fishway (South Fork Skykomish River at RM 51.5)
- Tulalip (Bernie Kai-Kai Gobin) Hatchery (RM 2.5 on Tulalip Creek, tributary to Tulalip Bay)
- Tulalip Creek upper and lower ponds (RM 0.1 on Tulalip Creek)
- Battle Creek Pond (RM 0.1 on Battle Creek, tributary to Tulalip Bay)
- Eagle Creek Hatchery (RM 0.4 on Eagle Creek, tributary to the Skykomish River at RM 28.3)
- Everett Bay Net-Pens (Mouth of the Snohomish River at Port Gardner Bay, Port of Everett Marina

Figure 1. Action area for the proposed continued operation of Snohomish River basin salmon hatcheries for fisheries harvest augmentation purposes. Map includes locations of all co-manager hatchery programs in the basin, two of which (Reiter Ponds and Tokul Creek Hatchery) are not operated as part of the proposed salmon hatchery actions. Source: WDFW Fish Program – September 16, 2016.

In addition, adult hatchery-origin only Chinook salmon would be collected in the Wallace River downstream of the Wallace River Hatchery and May Creek weirs through seining in years when adults were not volunteering to the traps at required broodstock collection levels. Adult Chinook salmon collected at Wallace River Hatchery would be released into the Wallace River upstream of the hatchery weir at RM 4.0 to allow the fish to spawn naturally. Monitoring and evaluation activities would be implemented at the hatcheries and in their immediate vicinities (i.e., Tulalip Bay, Wallace River), in Tulalip Creek, Battle Creek, and in the Snohomish River watershed extending from the mouth of the Snohomish River upstream to the limits of anadromous fish access in the Skykomish and Snoqualmie river watersheds.

NMFS considered whether pelagic marine waters of Puget Sound and the Pacific 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 any meaningful causal connection between hatchery production in the proposed action and any such effects.

2 Endangered Species Act: Biological Opinion, Conference Opinion, And Incidental Take Statement (ITS)

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 USFWS, NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions will affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires the consulting agency to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

2.1 Approach to the Analysis

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts on the conservation value of 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).

This biological opinion relies on the definition of "destruction or adverse modification", which is "a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214, February 11, 2016). We will use the following approach to determine whether the Proposed Action is likely to jeopardize a listed species or destroy or adversely modify critical habitat:

- First, the current status of listed species and designated critical habitat, relative to the conditions needed for recovery, are described in Section 2.2.
- Next, the environmental baseline in the action area is described in Section 2.3.

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

ESA-listed anadromous salmonid species in the action area (see Section 1.4) are described in Table 2. The effects of take associated with implementation of Puget Sound region hatchery salmon and steelhead production on the Hood Canal Summer Chum salmon ESU were previously evaluated and authorized by NMFS through a separate ESA section 7 consultation process (NMFS 2002a). An Environmental Assessment and FONSI were completed as part of the 2002 NMFS summer chum salmon consultation (NMFS 2002b). Effects on this ESA-listed species associated with implementation of the six salmon HGMPs will therefore not be discussed further in this biological opinion.

The ESA-listed threatened Coastal-Puget Sound bull trout (*Salvelinus confluentus*) DPS is administered by the U.S. Fish and Wildlife Service (USFWS). Effects on bull trout associated with the NMFS 4(d) rule determination for the proposed hatchery salmon programs have been addressed through a separate ESA section 7 consultation with USFWS. In a November 12, 2014 letter, NMFS requested consultation with USFWS regarding effects on listed species under USFWS regulatory purview (Jones 2014). "Take" of bull trout associated with NMFS's determination under the 4(d) rule for the proposed Snohomish River basin hatchery salmon programs was subsequently authorized by USFWS through a section 7 biological opinion (USFWS consultation reference number: OIEWFW00-2015-F-0120 (USFWS 2017). Research and monitoring specifically directed at bull trout in the action area are considered separate actions, which would be the subject of separate section 7 consultations. These actions will not be considered as part of the proposed steelhead hatchery-related actions considered in this opinion.

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

In analyzing the effects of the proposed actions on the Puget Sound Chinook salmon natural populations, NMFS considers its classification of each population and the role of the population in recovery of the ESU. Under the Population Recovery Approach (PRA) (NMFS 2010a), each natural population is assiged to a tier designation based on life history, production and habitat indicators, and the Puget Sound Recovery Plan biological delisting criteria (NMFS 2006a) (Figure 2). NMFS applies the PRA in ESA consultations for actions affecting ESA-listed Chinook salmon in Puget Sound (e.g., NMFS 2011b; NMFS 2015a). Although recognizing prioritization of the 22 Puget Sound Chinook salmon ESU populations is a necessity due to the lack of adequate funding available for listed species recovery, the Tulalip Tribes did not agree with application of the PRA for the Chinook salmon populations in the Snohomish River basin. The Tulalip Tribes disagreed with the PRA's application due to the need to first address tribal technical issues regarding population priortization metrics NMFS used in the approach, and policy issues pertaining to application of the PRA and treaty rights. NMFS considered the Tulalip Tribes' position, and other comments received, when the PRA was announced in 2010 as a proposed policy for public review. NMFS appreciates and understands that there are non-scientific factors (e.g., the importance of a salmon or steelhead populations to tribal culture and economics) that are important considerations in salmon and steelhead recovery.

Under the PRA, Tier 1 populations are of primary importance for preservation, restoration, and ESU recovery. Tier 2 populations play a secondary role in recovery of the ESU and Tier 3 populations play a tertiary role. When NMFS analyzes proposed actions, it evaluates impacts at the individual population scale for their effects on the viability of the ESU. Impacts to Tier 1 populations would be more likely to affect the viability of the ESU as a whole than similar impacts to Tier 2 or 3 populations, because of the primary importance of Tier 1 populations to overall ESU viability. Skykomish Chinook are classified through the approach as a Tier 2 population; Snoqualmie Chinook are a Tier 3 population (NMFS 2010a). These classifications for the two Chinook salmon populations that may be affected by the proposed actions are considered in NMFS's analysis with other factors (Section 2.6.1) to derive conclusions regarding Snohomish River basin salmon hatchery-related effects on the Puget Sound Chinook salmon ESU.

2.2 Range-wide Status of the Species and Critical Habitat

This opinion examines the status of each species and designated critical habitat that would be affected by the Proposed Action. The species and the designated critical habitat that are likely to be affected by the Proposed Action, and any existing protective regulations, are described in Table 3. 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.

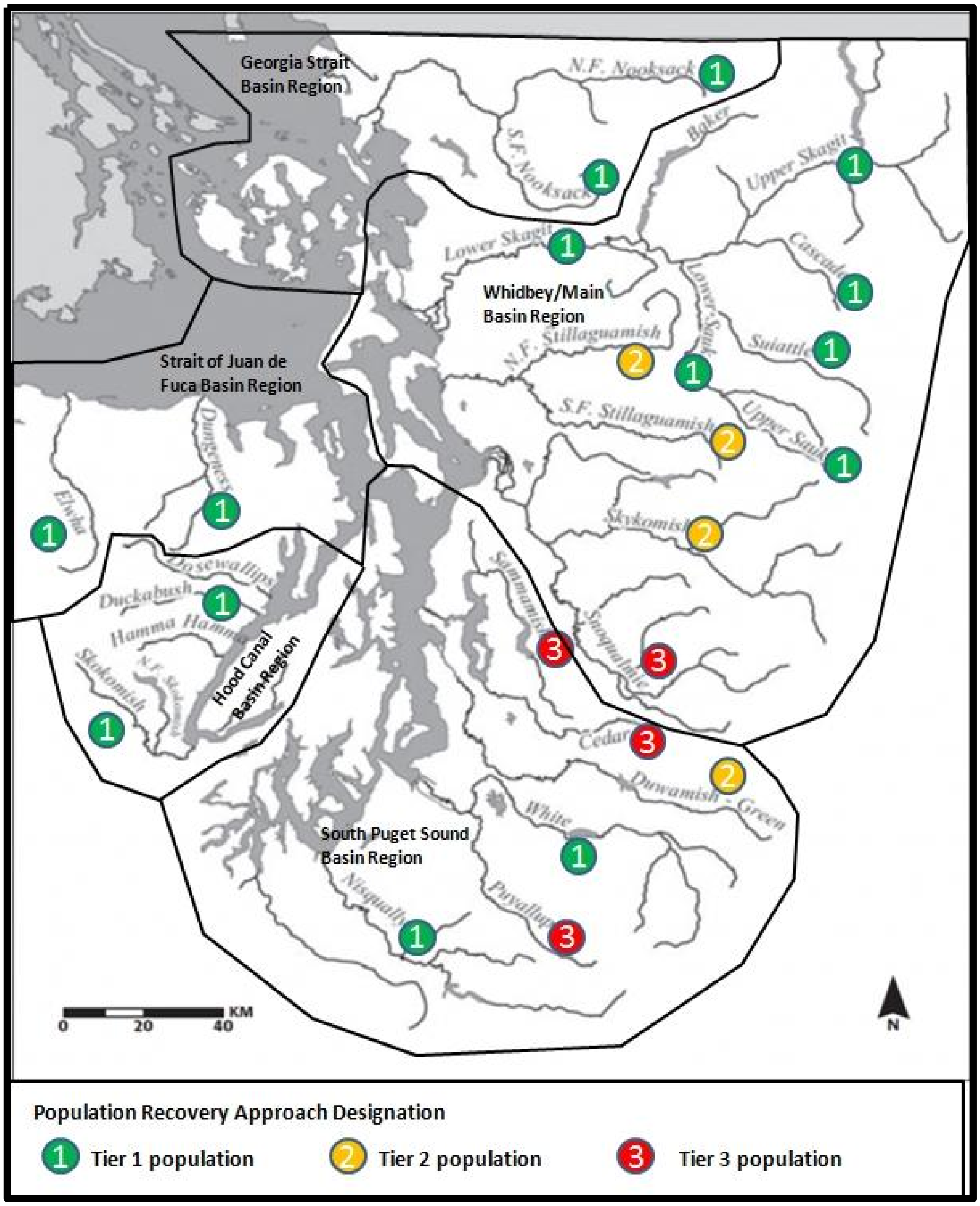

Figure 2. Populations delineated by NMFS for the Puget Sound Chinook salmon ESU (SSPS 2005b) and their assigned Population Recovery Approach tier status (NMFS 2010a). Note: Dosewallips, Duckabush and Hamma Hamma River Chinook salmon are aggregated as the "Mid Hood Canal" population.

Table 3. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to ESA listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulation
Chinook salmon (*Oncorhynchus tshawytscha*)			
Puget Sound	Threatened, March 24, 1999; 60 FR 14308	September 2, 2005; 70 FR 52630	June 28, 2005; 70 FR 37160
Steelhead (*Oncorhynchus mykiss*)			
Puget Sound	Threatened, May 11, 2007; 72 FR 26722	September 24, 2016; 81 FR 9252	September 25, 2008; 73 FR 55451

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

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

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

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

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

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

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

2.2.1 Puget Sound Chinook Salmon ESU

2.2.1.1 Life History and Status

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

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Based on best available scientific information, including these parameters that are indicators of species viability, NMFS determined that the Puget Sound Chinook Salmon ESU was a threatened species in 1999 (64 FR 14508). Since the time of listing, only three complete generations of Chinook salmon have returned, and the ESU remains at high risk and threatened in status (Ford et al. 2011; NWFSC 2015).

The NMFS adopted the recovery plan for Puget Sound Chinook salmon on January 19, 2007 (72 FR 2493). The recovery plan consists of two documents: the Puget Sound Salmon Recovery Plan prepared by the Shared Strategy for Puget Sound and NMFS’ Final Supplement to the Shared Strategy Plan. The

Recovery Plan describes the ESU's population structure, identifies populations essential to recovery of the ESU, establishes recovery goals for most of the populations, and recommends habitat, hatchery and harvest actions designed to contribute to the recovery of the ESU. It adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus et al. 2002). The PSTRT's Biological Recovery Criteria will be met when the following conditions are achieved:

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

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

3. At least one or more populations from major diversity groups[2] historically present in each of the five Puget Sound regions attain a low risk status;

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

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

Spatial Structure and Diversity. The PSTRT determined that 22 historical populations currently contain Chinook salmon and grouped them into five biogeographical regions (BGRs), based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity (Figure 2) (Table 4). Based on genetic and historical evidence reported in the literature, the TRT also determined that there were 16 additional spawning aggregations or populations in the Puget Sound Chinook Salmon ESU that are now putatively extinct[3] (Ruckelshaus et al. 2006). The 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, and rivers and streams flowing into Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington. We use the term ''Puget Sound'' to refer to this collective area of the ESU. As of 2017, there are 24 artificial propagation programs (described in individual HGMPs) producing Chinook salmon that are presently included, or proposed for inclusion as part of the listed ESU (81 FR 72759, October 21, 2016).

These programs are: Kendall Creek Hatchery Program; Skookum Creek Hatchery Spring-run Program; Marblemount Hatchery Program (spring subyearlings and summer-run); Brenner Creek Hatchery Program (fall-run); Whitehorse Springs Pond Program (summer-run); Wallace River Hatchery Program (yearlings and subyearlings); Bernie Kai-Kai Gobin (Tulalip) Hatchery-Cascade Program; the Bernie

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[2] Major diversity groups of Chinook salmon are identified based on run timing, age distribution, and migration patterns. For example, early returning and late returning populations of adult Chinook salmon represent two types of major diversity groups that may be present within a biogeographical region.

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

Kai-Kai Gobin (Tulalip) Hatchery Skykomish Program; Issaquah Hatchery Program; Soos Creek Hatchery Program (subyearlings and yearlings); Fish Restoration Facility Program; White River Hatchery Program; White Acclimation Pond Program; Hupp Springs Hatchery-Adult Returns to Minter Creek Program; Voights Creek Hatchery Program; Clark's Creek Hatchery Program; Clear Creek Program; Kalama Creek Program; George Adams Hatchery Program; North Fork Skokomish River Spring-run Program; Hamma Hatchery Program; Dungeness/Hurd Creek Hatchery Program; and the Elwha Channel Hatchery Program.

Table 4. Extant Puget Sound Chinook salmon populations by biogeographical region (NMFS 2006b).

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

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

Indices of spatial distribution and diversity have not been developed at the population level, though diversity at the ESU level is declining. Abundance is becoming more concentrated in fewer populations and regions within the ESU. Abundance has increased particularly within the Whidbey Basin Region (NWFSC 2015). During the last 5-year period (2010-2014) natural-origin escapement in the Strait of Georgia, Strait of Juan de Fuca, Hood Canal, Whidbey Basin, and Central-South Sound BGR's made up 1%, 1%, 2%, 70%, and 26% of the natural-origin escapement, respectively (from Table 56 *in* NWFSC

2015). There is a declining trend in the proportion of natural-origin spawners across the ESU during the entire time period from 1990 through 2014 (NWFSC 2015).

Abundance and Productivity. Table 5 and Table 6 summarize available scientific information on current abundance and productivity and their trends for the Puget Sound Chinook salmon natural populations including NMFS' critical and rebuilding thresholds and recovery plan targets for abundance and productivity. The information is summarized using updated estimates based on methodologies in the recent status reviews of West Coast salmon ESUs (Ford et al. 2011; NWFSC 2015) and recent escapement and fisheries data provided by tribal and state co-managers (data summarized in NMFS 2015a).

Most Puget Sound Chinook salmon natural populations are well below escapement levels identified as required for recovery to low extinction risk (Table 5). All populations are consistently below productivity goals identified in the recovery plan (Table 5). Although trends vary for individual populations across the ESU, most populations have declined in total natural origin recruit (NOR) abundance (prior to harvest) since the last status review. However, most populations exhibit a stable or increasing growth rate in natural-origin escapement (after harvest) (Table 6). No clear patterns in trends in escapement or abundance are evident among the five major regions of Puget Sound. No trend was notable for total ESU escapements. Trends in growth rate of natural-origin escapement are generally higher than growth rate of natural-origin abundance indicating some stabilizing influence on escapement from past reductions in fishing-related mortality (Table 6). Survival and recovery of the Puget Sound Chinook Salmon ESU will depend, over the long term, on necessary actions in all H sectors. Many of the habitat and hatchery actions identified in the Puget Sound Chinook salmon recovery plan are likely to take years or decades to be implemented and to produce significant improvements in natural population attributes (NWFSC 2015).

For the purpose of assessing population status, NMFS has derived critical and rebuilding escapement thresholds for some of the Puget Sound Chinook salmon populations based on an assessment of current habitat and environmental conditions (NMFS 2000; NMFS 2004; NMFS 2011). The most recent status review update in 2015 concluded that total abundance in the ESU over the entire time series shows that individual populations have varied from increasing or decreasing abundance; generally, many populations increased in abundance during the years 2000 through 2008 and then declined in the last five years (NWFSC 2015). Abundance across the ESU has generally decreased since the last status review, with only 5 populations showing an increase in the 5-year geometric mean natural-origin abundance since the 2010 status review (NWFSC 2015). The remaining 17 populations showed a decline in their 5-year geometric mean natural-origin abundance as compared to the previous 5-year period. The 5-year geometric mean abundance for the entire ESU was 27,716 natural-origin adults from 2005 through 2009 and only 19,258 from 2010 through 2014; indicating an overall decline of -31% (from Table 56 *in* NWFSC 2015). Geometric mean (1999-2014) natural-origin escapements for 5 of the 22 populations are above their NMFS-derived rebuilding thresholds (Table 6). Geometric mean (1999-2014) escapements for ten of the 22 populations are between their critical and rebuilding thresholds. Geometric mean (1999-2014) natural-origin escapements are below their critical thresholds for seven populations (Table 6). The most recent geometric mean (2010-2014) natural-origin escapements indicate that 8 populations are currently below their critical thresholds.

Table 5. Estimates of escapement and productivity for Puget Sound Chinook salmon. Natural origin escapement information is provided where available. For several populations, data on hatchery contribution to natural spawning are limited or unavailable. Source: NMFS 2015a.

Region	Population	1999 to 2014 Geometric mean Escapement (Spawners)		NMFS Escapement Thresholds		Recovery Planning Abundance Target in Spawners (productivity)[2]	Average % hatchery fish in escapement 1999-2013 (min-max)[5]
		Natural[1]	Natural-Origin (productivity[2])	Critical[3]	Rebuilding[4]		
Georgia Basin	Nooksack MU	1,937	268	*400*	500		
	NF Nooksack	1,638	211 (0.3)	*200*[6]	-	3,800 (3.4)	85 (63-94)
	SF Nooksack	399	53 (1.7)	*200*[6]	-	2,000 (3.6)	84 (62-96)
Whidbey/ Main Basin	Skagit Summer/Fall MU	7,976	7,748[8] (1.8)	967	7,454	5,380 (3.8)	3 (1-8)
	Upper Skagit River	543	552[8] (1.8)	*200*[6]	681	1,400 (3.0)	1 (0-10)
	Lower Sauk River	1,993	1,932[8] (1.4)	251	2,182	3,900 (3.0)	4 (2-8)
	Lower Skagit River						
	Skagit Spring MU	522	502[8] (1.6)	130	330	750 (3.0)	1 (0-5)
	Upper Sauk River	327	319[8] (1.2)	170	400	160 (3.2)	2 (0-5)
	Suiattle River	290	291[8] (1.1)	170	*1,250*[6]	290 (3.0)	8 (0-25)
	Upper Cascade River						
	Stillaguamish MU	952	582 (0.9)	300	552	4,000 (3.4)	35 (8-62)
	NF Stillaguamish R.	110	**104** (0.7)	*200*[6]	300	3,600 (3.3)	NA
	SF Stillaguamish R.						
	Snohomish MU	3,367	2,052[8] (0.9)	1,650	3,500	8,700 (3.4)	30 (8-36)
	Skykomish River	1,583	1,142[8] (1.5)	400	*1,250*[6]	5,500 (3.6)	19 (3-62)
	Snoqualmie River						
Central/ South Sound	Cedar River	842	802[8] (1.9)	*200*[6]	*1,250*[6]	2,000 (3.1)	20 (10-36)
	Sammamish River	1,172	128[8] (0.5)	*200*[6]	*1,250*[6]	1,000 (3.0)	86 (66-95)
	Duwamish-Green R.	3,562	1,179[8] (1.1)	835	5,523	-	57 (33-75)
	White River[9]	1,753	1,268[8] (0.6)	*200*[6]	1,100[7]	-	39 (15-49)
	Puyallup River [10]	1,570	655[8] (0.8)	*200*[6]	522[7]	5,300 (2.3)	53 (18-77)
	Nisqually River	1,687	522[8] (1.0)	*200*[6]	1,200[7]	3,400 (3.0)	72 (53-85)
Hood Canal	Skokomish River	1,305	345 (0.8)	452	1,160	-	66 (7-95)
	Mid-Hood Canal R.[11]	175		*200*[6]	*1,250*[6]	1,300 (3.0)	66
Strait of Juan de Fuca	Dungeness River	354	114[8] (0.6)	*200*[6]	925[7]	1,200 (3.0)	67 (39-96)
	Elwha River[12]	1,919	117[8] (NA)	*200*[6]	*1,250*[6]	6,900 (4.6)	94 (92-95)

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

Table 6. Trends in abundance and productivity for Puget Sound Chinook salmon populations. Long-term, reliable data series for natural-origin contributions to escapement are limited in many areas. Green, yellow and red highlights indicate increasing, stable, and declining trends (Source: NMFS 2015a).

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

[1] Escapement Trend is calculated based on all spawners (i.e., including both natural-origin spawners and hatchery-origin fish spawning naturally) to assess the total number of spawners passed through the fishery to the spawning ground. Directions of trends defined by statistical tests.
[2] Growth rate (λ) is calculated based on natural-origin production assuming the reproductive success of naturally spawning hatchery fish is equivalent to that of natural-origin fish (for populations where information on the fraction of hatchery fish in natural spawning abundance is available). Source: Abundance and Productivity Tables-Puget Sound TRT).
[3] Estimate of the fraction of hatchery fish in time series is not available for use in λ calculation, so trend represents that in hatchery-origin + natural-origin spawners.
[4] Growth rate estimates for Sammamish have not been revised to include escapement in Issaquah Creek.
[5] Natural spawning escapement includes an unknown fraction of naturally spawning hatchery-origin fish from late- and early run hatchery programs in the Puyallup River basin

Limiting factors. Limiting factors described in SSPS (2007) and NMFS (2011a) include:

- Degraded nearshore and estuarine habitat: Residential and commercial development has reduced the amount of functioning nearshore and estuarine habitat available for salmon rearing and migration. The loss of mudflats, eelgrass meadows, and macroalgae further limits salmon foraging and rearing opportunities in nearshore and estuarine areas.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, and water quality have been degraded for adult spawning, embryo incubation, and rearing as a result of cumulative impacts of agriculture, forestry, and development.
- Anadromous salmonid hatchery programs: Salmon and steelhead released from Puget Sound hatcheries operated for harvest augmentation purposes pose ecological, genetic, and demographic risks to natural-origin Chinook salmon populations.
- Salmon harvest management: Total fishery exploitation rates have decreased 14 to 63 percent from rates in the 1980s, but weak natural-origin Chinook salmon populations in Puget Sound still require enhanced protective measures to reduce the risk of overharvest.

The severity and relative contribution of these factors varies by natural population. In addition, cycles or variability in environmental conditions affecting plant and animal communities, for example increased predator abundances and decreased food resources in ocean rearing areas, likely y have contributed to declines in fish populations in Puget Sound, particularly during the 1980s and into the 1990s. For a comprehensive treatment of all limiting factors, please see Section 2.3, Environmental Baseline.

Whidbey Basin BGR: The Whidbey Basin BGR contains 10 populations including the two Snohomish populations. The Suiattle and at least one other population within the Whidbey Basin (one each of the early, moderately early and late spawn-timing) would need to be viable for recovery of the ESU. Evidence suggests that the Puget Sound Chinook Salmon ESU has lost 15 spawning aggregations that were either demographically independent historical populations or major components of the life history diversity of the remaining 22 extant independent historical populations identified (Ruckelshaus et al. 2006). Nine of the 15 putatively extinct spawning aggregations were thought to be early type Chinook salmon. The majority of extant populations with early run-timing are in this BGR and it currently accounts for about 47 percent and just under 70 percent of the all-natural spawners and natural-origin Chinook salmon escapement in the ESU, respectively (Table 56 *in* NWFSC 2015).

Considering abundance in a number of different ways, for example short-term geometric means versus long-term population growth rates, the data do not support any particular conclusion across the BGR. Abundance varies greatly among the populations (Table 5) with the Skagit populations comprising the majority (76%) of Chinook salmon in the BGR (NWFSC 2015). Based on estimates of the most recent 5-year (2010-2014) geometric mean abundances, two populations in the BGR are above their rebuilding thresholds (representing early and moderately early life histories) and the South Fork Stillaguamish is in critical status (WDFW Score Database; NWFSC 2015). As described above, only 5 populations showed an increase in abundance in the 5-year geometric mean natural-origin abundance since the 2010 status review (NWFSC 2015), and 3 of these 5 are within the Whidbey Basin BGR. Long-term (1990-2013) escapement trends are increasing or stable for all but the South Fork Stillaguamish population (Table 6). Long-term growth rates for pre-harvest abundance (return) are declining for all populations within the

BGR except for the Skykomish River (NMFS 2015a). Growth rates for escapement are stable or increasing for all populations within the BGR except for the Suiattle and South Fork Stillaguamish populations. In summary, the Whidbey Basin BGR is a stronghold of the ESU in terms of life history diversity, spatial structure, and abundance

Snohomish River Basin Chinook - The two Snohomish River basin Chinook salmon populations – Skykomish and Snoqualmie – are grouped with eight other populations in the Whidbey Basin BGR for recovery planning purposes (NMFS 2006b; SSPS 2005). Based on analyses of population and habitat status factors for Chinook salmon populations grouped within the Whidbey Basin BGR, under the NMFS PRA (NMFS 2010a), the populations affected by this proposed action, the Skykomish and Snoqualmie Chinook populations, are Tier 2 and Tier 3 populations, respectfully. Within the Whidbey Basin BGR, Chinook salmon populations in the Skagit River are assigned as having primary roles for Puget Sound Chinook salmon ESU recovery and are designated as Tier 1 (Figure 2). As described in Section 2.1, impacts to Tier 2 and 3 populations would be less likely to affect the viability of the ESU as a whole than similar impacts to Tier 1 populations, because of the primary importance of Tier 1 populations to overall ESU viability.

Both the Skykomish and Snoqualmie populations are ocean-type Chinook salmon with juveniles emigrating seaward in March through June. A significant proportion of adult Chinook salmon in each population, averaging 24% and 22% for the Skykomish and Snoqualmie populations, respectively (1996-2011 averages from Mike Crewson, Tulalip Tribes and Pete Verhey, WDFW, pers. comm., 2014), is comprised by the yearling fresh water life history type ("stream type"). Adults return primarily as four-year-old fish, although both populations exhibit a relatively strong age-5 component. For the period 2005 through 2013, age-5 Chinook salmon made up 20- and 17-percent of the natural-origin spawners in the Skykomish and Snoqualmie populations, respectively (Rawson and Crewson 2014).

Adult summer Chinook salmon return to the Skykomish River watershed beginning in May and extending through July (PSIT and WDFW 2010). The Skykomish natural population has a late-summer/early-fall spawn timing (August through September) with Chinook salmon spawning in the Snohomish River mainstem, the mainstem of the Skykomish, Pilchuck, Wallace, and Sultan rivers; Woods, Elwell, Olney, Proctor, and Bridal Veil creeks; and the North and South Forks of the Skykomish River (WDFW spawning ground database). The Snoqualmie Chinook salmon population is considered a fall-run stock, migrating into the Snohomish River basin from August through October. Chinook salmon spawning occurs later than in the Snoqualmie River watershed, generally in the fall months (mid/late-September through early-November) (WDFW spawning ground database). Snoqualmie Chinook salmon spawn in the Snoqualmie River and its larger tributaries, including the Tolt and Raging rivers, and Tokul Creek (PSIT and WDFW 2010).

Abundance of Snohomish River basin Chinook salmon is a fraction of historical levels (SSPS 2005) (Figure 3 and Figure 4). The most recent estimates of escapement, hatchery contribution, and productivity for the Snohomish Basin populations are summarized in Table 7 and Table 8. Naturally-produced Chinook salmon comprise a majority of natural spawners, averaging 74.5 percent for the basin in recent years (2006-2014; see Table 7). The average hatchery-origin fraction of the naturally spawning Skykomish Chinook salmon population in the last eight recent years (2006-2014; 27.8%) has decreased by nearly half from the level 15 years ago (1997-2001 avg. = 49.9%). The hatchery-origin fraction of the naturally spawning Snoqualmie Chinook salmon population has largely remained consistent over the last 17 years. A moderate increase was observed in recent years (20.4 percent from 2005-2014) relative to the 1997-2001 average of 15.6 percent (Tulalip 2012; Tulalip Tribes, unpublished data 2016). This increase can be attributed to lower numbers of natural-origin spawners in recent years; as the actual number of hatchery-origin spawners declined by 6.0 percent for the period 2005-2014 relative to the 1997-2001 period.

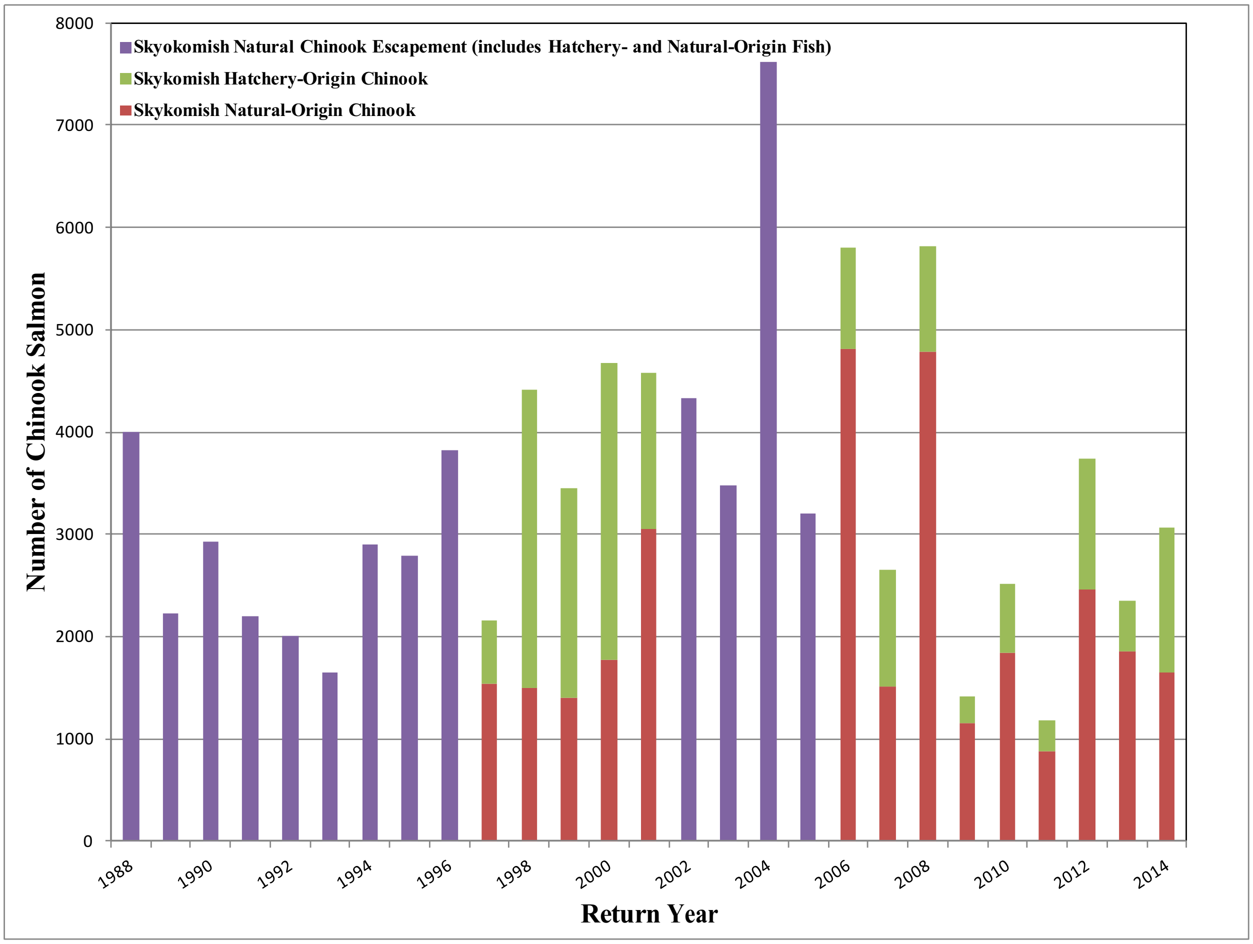

Figure 3. Estimated annual natural Chinook salmon escapement abundances in the Skykomish River for 1988 through 2014. Natural- and hatchery-origin breakouts are included for years where data are available. Source Tulalip 2012; Mike Crewson and Pete Verhey, Tulalip Tribes and WDFW unpublished escapement data 2016.

Trends in annual natural-origin spawner per natural spawner rates for the Skykomish and Snoqualmie populations indicate general declines in productivity (Table 8). For brood years 2000 through 2010, in all but two brood years, both the Skykomish and Snoqualmie Chinook populations have been averaging less than 1:1 natural origin recruits to escapement per natural spawner. The 2006-2010 brood year geometric mean natural origin recruit spawner per natural spawner level for the Skykomish Chinook population was 0.5201 (K. Rawson, for the Tulalip Tribes, pers. comm., May 22, 2017). For the Snoqualmie Chinook population, the 2006-2010 brood year geometric mean natural origin recruit spawner per natural spawner level was 0.4691.

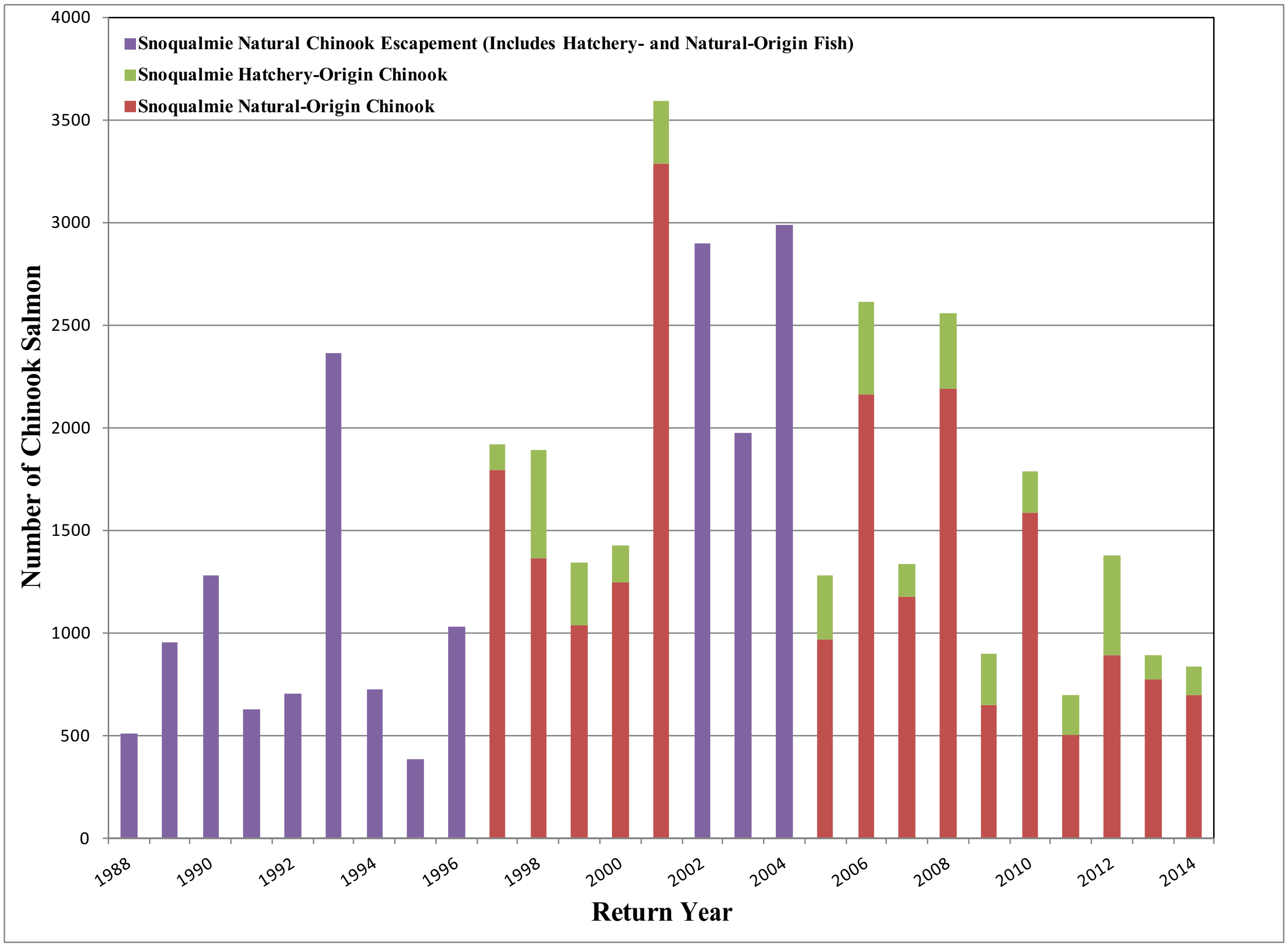

Figure 4. Estimated annual natural Chinook salmon escapement abundances in the Snoqualmie River for 1988 through 2014. Natural- and hatchery-origin breakouts are included for years where data are available. Source Tulalip 2012; Mike Crewson and Pete Verhey, Tulalip Tribes and WDFW unpublished escapement data 2016.

Table 7. Summary of Skykomish and Snoqualmie populations natural escapement, natural-origin escapement, and percent of natural escapement composed of hatchery-origin spawners (pHOS) for return years 1997-2014 (where estimates are available). Source Tulalip Tribes 2012; Mike Crewson and Pete Verhey, Tulalip Tribes and WDFW unpublished escapement data 2015).

Return Year	Skykomish Total Natural Escapement	Skykomish Natural-Origin Escapement	Skykomish Percent Hatchery-Origin	Snoqualmie Total Natural Escapement	Snoqualmie Natural-Origin Escapement	Snoqualmie Percent Hatchery-Origin
1997	2,161	1,540	28.7%	1,917	1,796	6.3%
1998	4,415	1,495	66.1%	1,891	1,361	28.0%
1999	3,446	1,401	59.3%	1,345	1,040	22.7%
2000	4,668	1,775	62.0%	1,427	1,248	12.5%
2001	4,577	3,054	33.3%	3,589	3,284	8.5%
2002	4,327	NA	NA	2,896	NA	NA
2003	3,472	NA	NA	1,975	NA	NA
2004	7,614	NA	NA	2,988	NA	NA
2005	3,201	NA	NA	1,279	968	24.3%
2006	5,573	4,642	16.7%	2,615	2,161	17.4%
2007	2,648	1,510	43.0%	1,334	1,174	12.0%
2008	5,813	4,780	17.8%	2,560	2,190	14.5%
2009	1,414	1,146	19.0%	895	649	27.5%
2010	2,511	1,836	26.9%	1,788	1,585	11.3%
2011	1,176	876	25.5%	702	479	31.8%
2012	3,738	2,462	34.1%	1,379	898	34.9%
2013	2,355	1,860	21.0%	889	770	13.4%
2014	3,063	1,654	46.0%	839	698	16.8%
1997-2001 Skykomish pHOS			49.9%			
2006-2014 Skykomish pHOS			27.8%			
			1997-2001 Snoqualmie pHOS			15.6%
			2005-2014 Snoqualmie pHOS			20.4%
1997-2001 Basin Wide pHOS			38.9%			
2006-2014 Basin Wide pHOS			25.5%			

Table 8. Recent productivity estimates for Skykomish and Snoqualmie Chinook salmon populations as measured by the annual number of natural-origin recruit spawners (NOR) per natural-origin spawners for the contributing brood year (source: Rawson and Crewson 2017).

	Skykomish Chinook			Snoqualmie Chinook		
Brood Year[4]	NOR Spawner Abundance 1/	Natural Spawner Abundance	NOR Spawner/Natural Spawner	NOR Spawner Abundance 1/	Natural Spawner Abundance	NOR Spawner/Natural Spawner
2000	6,271	4,668	1.3434	2,361	1,427	1.655
2001	2,253	4,577	0.4921	890	3,589	0.248
2002	3,716	4,327	0.8587	2,209	2,896	0.763
2003	1,642	3,472	0.4728	854	1,975	0.432
2004	5,565	7,614	0.7308	2,259	2,988	0.756
2005	2,336	3,201	0.7297	1,264	1,279	0.988
2006	1,271	5,573	0.2280	1,094	2,615	0.418
2007	1,348	2,648	0.5090	609	1,334	0.456
2008	2,432	5,813	0.4184	740	2,560	0.289
2009	2,838	1,414	2.0074	1,097	895	1.225
2010	981	2,511	0.3907	536	1,788	0.300

1/ NOR spawner progeny of brood year natural spawners summed for all observed age classes at return.

The spatial structure for the Skykomish and Snoqualmie Chinook salmon natural populations has been reduced by habitat loss and degradation. Bank protection and diking of the river and major tributaries have disconnected river channels from their floodplains leading to loss of accessible river areas and habitat complexity for rearing and migrating Chinook salmon (Snohomish Basin Salmonid Recovery Technical Committee [SBSRTC] 1999). Lack of adequate in-channel large woody debris, relative to historic conditions, has decreased the amount of rearing and refuge areas available for juvenile Chinook salmon (SBSRTC 1999). Chinook habitat has been further reduced by loss of wetlands through draining and land conversion for human use (SBSRTC 1999). Road construction, commercial and residential construction, and bank hardening for flood control have also impaired Chinook salmon habitat use and access and population spatial structure. Artificial barriers at locations throughout the Basin, including dams, tide gates, water diversions, culverts, and pumping stations) prevent juvenile Chinook salmon from reaching rearing habitat to the further detriment of population spatial structure (SBSRP 2005). Since the 1950s, the spawning distribution of the Skykomish Chinook salmon population appears to have shifted upstream. Since that time, a much larger proportion of fish spawn higher in the drainage, between Sultan and the North and South Forks of the Skykomish River, than in previous decades (SBSRTC 1999).

Life history diversity of the Snohomish River basin Chinook salmon populations has been reduced by anthropogenic activities over the last century (Haring 2002, citing J. Houghton and M. Chamblin), and is further threatened by on-going developmental actions in the watershed. Lost and degraded estuarine habitat has impaired the fry migrant components of the Skykomish and Snoqualmie populations, which

[4] Brood year indicates the year the individual was born. This table includes data collected through 2015, which for example included 5-year-old returning adult Chinook salmon from the 2010 brood year.

need a properly functioning, braided lower river and brackish water environment to grow to a viable smolt size. Fry migrants represent a particularly important component of the life history diversity for both populations.

The Chinook salmon populations in the Snohomish River basin have been particularly affected by habitat loss in the estuary. The quantity and quality of salmon rearing habitat available to the two populations in the estuary is a small fraction of pre-development conditions (Snohomish County 2013). Historically, the Snohomish River estuary included a rich complex of tidal channels and productive marshes. Under current conditions, only one-sixth of the historical tidal marsh area downstream of the head of Ebey Slough remains intact and accessible to salmonids (Snohomish County 2013). The current lack of critical estuarine tidal marsh habitat is considered a limiting factor for Chinook salmon recovery (SBSRP 2005). These conditions compromise prospects for restoration of natural-origin Chinook salmon population viability, because ocean-type Chinook salmon stocks are extremely dependent on a properly functioning estuary due to their predominantly fry migrant life history.

2.2.1.2 Status of Critical Habitat for Puget Sound Chinook Salmon

Designated critical habitat for the Puget Sound Chinook ESU includes estuarine areas and specific river reaches associated with the following subbasins: Strait of Georgia, Nooksack, Upper Skagit, Sauk, Lower Skagit, Stillaguamish, Skykomish, Snoqualmie, Snohomish, Lake Washington, Duwamish, Puyallup, Nisqually, Deschutes, Skokomish, Hood Canal, Kitsap, and Dungeness/Elwha (70 FR 52630, September 2, 2005). The designation also includes some nearshore areas, adjacent to watersheds occupied by the 22 populations and extending from extreme high water out to a depth of 30 meters, because of their importance to rearing and migrating juvenile Chinook salmon and their prey, but does not otherwise include offshore marine areas. There are 61 watersheds within the range of this ESU. Twelve watersheds received a low rating, nine received a medium rating, and 40 received a high rating of conservation value to the ESU (NMFS 2005a). Nineteen nearshore marine areas also received a rating of high conservation value. Of the 4,597 miles of stream and nearshore habitat eligible for designation, 3,852 miles are designated critical habitat (NMFS 2005b).

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

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

(3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival;
(4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.
(5) Nearshore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.
(6) Offshore marine areas with water-quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

Critical habitat is designated for Puget Sound Chinook salmon within the Snohomish River basin action area. Critical habitat includes the estuarine areas and the stream channels within the proposed stream reaches of the Snohomish sub-basin, and includes a lateral extent as defined by the ordinary high-water line (33 CFR 319.11). The Puget Sound Critical Habitat Analytical Review Team identified management activities that may affect the PCEs in the three subbasins including agriculture, grazing, channel modifications/diking, dams, forestry, urbanization, sand/gravel mining and road building/maintenance (NMFS 2005a).

2.2.2 Puget Sound Steelhead DPS

2.2.2.1 Life History and Status

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

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

The Puget Sound steelhead DPS was listed as threatened in May of 2007 (72 FR 26722). Recovery planning for Puget Sound steelhead has produced a great deal of information. As part of the recovery planning process, NMFS convened the Puget Sound Steelhead Technical Recovery Team (PSSTRT) to identify historical populations and develop viability criteria for the recovery plan. The final technical team report describing historical population structure was released in March 2015 (Myers et al. 2015). NMFS also released the final PSSTRT report describing viability criteria for Puget Sound steelhead in May 2015 (Hard et al. 2015).

No new estimates of productivity, spatial structure and diversity of Puget Sound steelhead have been made available since the 2007 review, when the BRT concluded that low and declining abundance and low and declining productivity were substantial risk factors for the DPS/species (Hard et al. 2007). Loss of diversity and spatial structure were judged to be "moderate" risk factors due to reduced complexity and diminishing connectivity among populations, influences of non-native hatchery programs and the low numbers of summer steelhead populations in the Puget Sound DPS (Hard et al. 2007). The 2011 status review (Ford et al. 2011) determined that the DPS should remain in threatened status. The PSSTRT recently concluded that the DPS was at very low viability, as were all three of its MPGs, and many of the "Demographically Independent Populations" (DIPs) (Hard et al. 2015; Table 9).

The PSSTRT has completed a set of population viability analyses (PVAs) for these draft populations and major population groups (MPGs) within the DPS. The roles of individual populations in recovery of the Puget Sound steelhead DPS have not yet been defined, in contrast to the approach applied to delineate populations within the Puget Sound Chinook salmon ESU using the PRA (NMFS 2010a). However, the PSSTRT developed interim abundance-based guidelines for various potential recovery scenarios stating that in order for the DPS to achieve full recovery, steelhead populations in the DPS need to be robust enough to withstand natural environmental variation and even some catastrophic events, and should be resilient enough to support harvest and habitat loss due to human population growth (Hard et al. 2015). In winter 2015, the Northwest Fishery Science Center completed an updated five-year review of the status of the DPS. This status review update concludes that biological risks faced by the DPS have not substantively changed since listing in 2007, and the viability status of the DPS and component MPGs continued to be very poor (NWFSC 2015).

Table 9. Puget Sound steelhead populations and risk of extinction (Hard et al. 2015).

Major Population Groups (MPGs)	Population (Run Time)	Extinction Risk (probability of decline to an established quasi-extinction threshold (QET) for each population)	Quasi-extinction threshold (number of fish)
Northern Cascades	Drayton Harbor Tributaries (winter)	Unable to calculate	
	SF Nooksack River (summer)	Unable to calculate	
	Nooksack River (winter)	Unable to calculate	
	Samish River/Bellingham Bay (winter)	Low—about 30% within 100 years	31
	Skagit River (summer/winter)	Low—about 10% within 100 years.	157
	Baker River (summer/winter)	Unable to calculate	
	Sauk River (summer/winter)	Unable to calculate	
	Snohomish/Skykomish River (winter)	Low—about 40% within 100 years	73
	Stillaguamish River (winter)	High—about 90% within 25 years	67
	Deer Creek (summer)	Unable to calculate	
	Canyon Creek (summer)	Unable to calculate	
	Tolt River (summer)	High—about 80% within 100 years	25
	NF Skykomish River (summer)	Unable to calculate	
	Snoqualmie (winter)	High---about 70% within 100 years	58
	Nookachamps (winter)	Unable to calculate	--
	Pilchuck (winter)	Low---about 40% within 100 years	34
Central and Southern Cascades	North L. Washington/L. Sammamish (winter)	Unable to calculate	
	Cedar River (summer/winter)	High---about 90% within the next few years	36
	Green River (winter)	Moderately High—about 50% within 100 years	69
	Nisqually River (winter)	High—about 90% within 25 years	55
	Puyallup/Carbon River (winter)	High—about 90% within 25-30 years	
	White River (winter)	Low—about 40% within 100 years	64
	South Sound Tributaries (winter)	Unable to calculate percentage	--
	East Kitsap (winter)	Unable to calculate	
Hood Canal and Strait of Juan de Fuca	Elwha River (summer[5]/winter)	High— about 90% currently	41
	Dungeness River (summer/winter)	High—about 90% within 20 years	30
	South Hood Canal (winter)	High---about 90% within 20 years	30
	West Hood Canal (winter)	Low—about 20% within 100 years	32
	East Hood Canal (winter)	Low—about 40% within 100 years	27
	Skokomish River (winter)	High—about 70% within 100 years	50
	Sequim/Discovery Bay Independent Tributaries (winter)	High—about 90% within 100 years (Snow Creek)	25 (Snow Creek)
	Strait of Juan de Fuca Independent Tributaries (winter)	High—about 90% within 60 years (Morse & McDonald creeks)	26 (Morse & McDonald Ck)

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

Spatial Structure and Diversity. The Puget Sound steelhead DPS includes all naturally spawned anadromous winter-run and summer-run steelhead populations within streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive) (Figure 5). Also included as part of the ESA-listed DPS are six hatchery-origin stocks that are derived from and integrated with local natural steelhead populations, including fish from the Green River Natural Program; White River Winter Steelhead Supplementation Program; Hood Canal Steelhead Supplementation Off-station Projects in the Dewatto, Skokomish, and Duckabush Rivers; and the Lower Elwha Fish Hatchery Wild Steelhead Recovery Program (FR 79 20802, April 14, 2014). Non-anadromous ''resident'' *O. mykiss* occur within the range of Puget Sound steelhead but are not part of the DPS due to marked differences in physical, physiological, ecological, and behavioral characteristics (Hard et al. 2007). Puget Sound steelhead populations are aggregated into three extant MPGs containing a total of 32 DIPs based on genetic, environmental, and life history characteristics ((PSSTRT 2013a) (Table 9). DIPs can include summer steelhead only, winter steelhead only, or a combination of summer and winter run timing (i.e., summer/winter).

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

The 2015 NMFS Puget Sound steelhead status review (NWFSC 2015) concluded that the most recent data available indicate some minor increases in spawner abundance and/or improving productivity over the last two to three years for Puget Sound steelhead; however, most of these improvements are viewed as small and abundance and productivity throughout the DPS remain at levels of concern. The recent increases in abundance observed in a few populations are encouraging, however they are generally within the range of variability observed in the past several years and overall trends in abundance of natural-origin spawners remain predominately negative (NWFSC 2015). Changes in hatchery production for both summer-run and winter-run hatchery steelhead, in particular reductions in the number of early-winter and Skamania summer hatchery fish released, as well as reduced harvest, have reduced adverse effects on natural populations in recent years. In general, the biological status of the Puget Sound Steelhead DPS has not substantively changed since the listing in 2007, or since the 2011 status review (NWFSC 2015).

Limiting factors. In its status review and listing documents for the Puget Sound Steelhead DPS (e.g., Ford et al. 2011; 76 FR 1392; 71 FR 15666), NMFS noted that the factors for decline for the DPS also persist as limiting factors:

- In addition to being a factor that contributed to the present decline of Puget Sound steelhead natural populations, the principal factor limiting the viability of the Puget Sound steelhead DPS is the continued destruction and modification of steelhead habitat.
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years.
- Threats to diversity from two hatchery steelhead stocks (Chambers Creek and Skamania).

- Declining diversity in the DPS, including the uncertain but weak status of summer-run fish in the DPS.

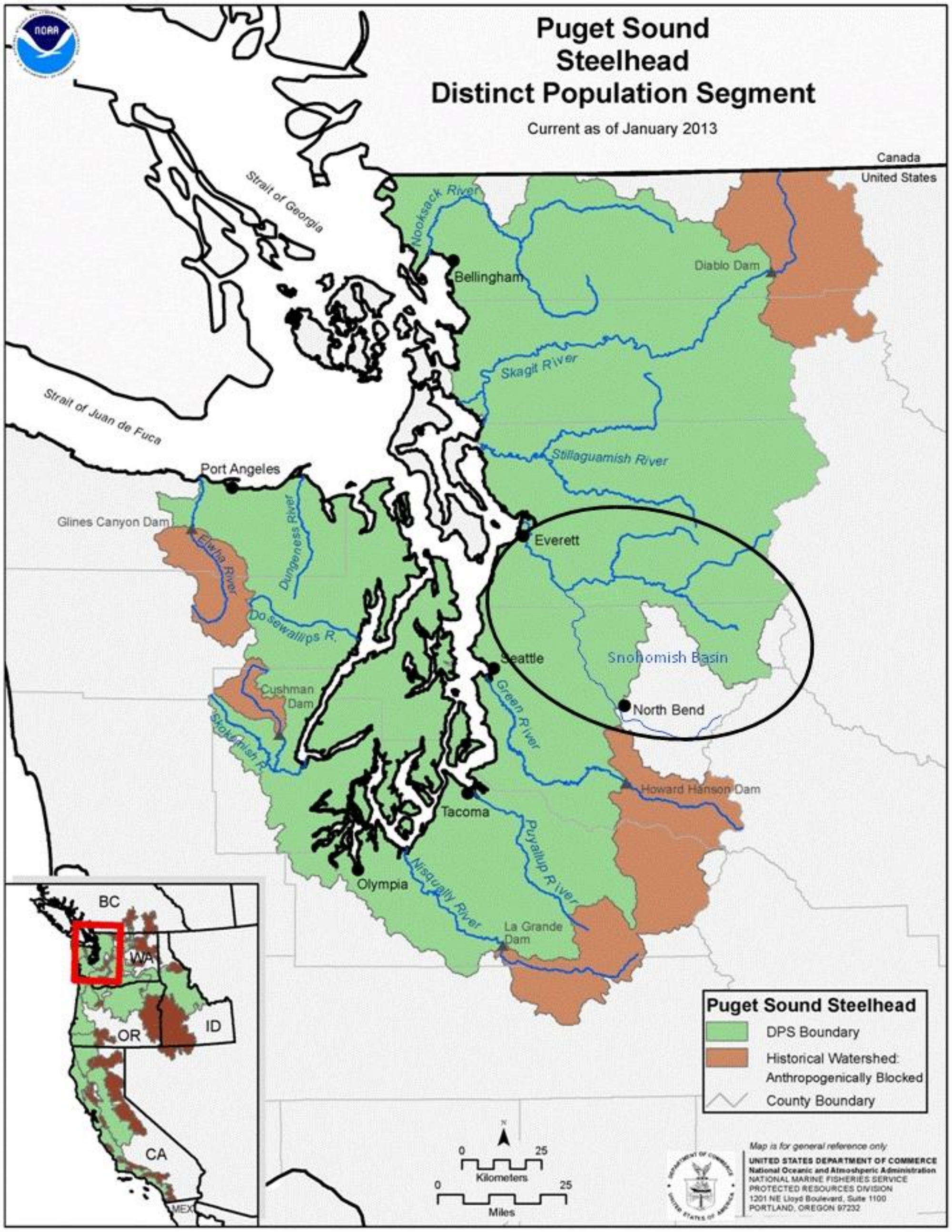

Figure 5. Location of the Snohomish River steelhead populations in the Puget Sound Steelhead DPS (generalized location indicated by black oval).

- A reduction in spatial structure for steelhead in the DPS. Large numbers of barriers, such as impassable culverts, together with declines in natural abundance, greatly reduce opportunities for adfluvial movement and migration between steelhead groups within watersheds.
- Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris.
- Increased flood frequency and peak flows during storms, and reduced groundwater-driven summer flows in the lower reaches of many rivers and their tributaries in Puget Sound where urban development has occurred, has resulted in gravel scour, bank erosion, and sediment deposition.
- Dikes, hardening of banks with riprap, and channelization, which have reduced river braiding and sinuosity, have increased the likelihood of gravel scour and dislocation of rearing juveniles.

Northern Cascades MPG

The Northern Cascades MPG has 16 DIP's including eight summer or summer/winter, and eight winter DIPs (Table 9). Differences in bedrock erodibility throughout the Northern Cascades MPG create cascades and falls that may serve as isolating mechanisms for summer-and winter-run populations. This geology is likely responsible for the relatively large number of summer-run populations (PSSTRT 2013a) since returning summer steelhead tend to migrate to headwater areas in the spring and early-summer when flows are higher, making possible access to upstream areas that, in other months, are impassable due to low flow related obstacles to passage that become partial or complete barriers to migration. Eight of the 10 DIPs in the DPS with extant summer run-timing or summer components are in this MPG. The Northern Cascade MPG accounts for 75 percent of the steelhead abundance in the DPS (NWFSC 2015). Although information on the DIPs within the Northern Cascades MPG is extremely limited, abundance varies greatly among the populations (Table 10) with the Skagit and Snohomish natural populations comprising the majority of steelhead in the MPG. Mean growth rates are declining for all populations within the MPG except for the Tolt River, and abundance for this DIP is very low. Through the most recent five year species status review, abundance trends from 1999 through 2014 for three DIPs within the MPG were evaluated (NWFSC 2015). Two of the DIPs had negative long-term trends and one had a positive long-term trend (Samish). Between the two most recent five-year periods (2004-2009 and 2010-2014), the geometric mean of estimated abundance for eight DIPs evaluated increased by an average of 3% in the North Cascades MPG (NWFSC 2015). Risk assessment by the PSSTRT indicated three populations are at high risk of extinction and four are at low risk (Table 10) with the Snohomish populations equally divided. However, more natural populations are at lower risk in this MPG than in the other MPGs in the DPS. In summary, the North Cascades steelhead MPG, relatively speaking, is at a lower extinction risk and is a stronghold in terms of life history diversity and abundance.

Snohomish Basin Populations

The Snohomish Basin includes five steelhead DIPs: Snohomish/Skykomish winter-run; Pilchuck winter-run; Snoqualmie winter-run; Tolt summer-run; and North Fork Skykomish summer-run ((PSSTRT 2013a). The DPS viability criteria developed by NMFS (Hard et al. 2015), require that at least 40 percent of the steelhead populations within each MPG achieve viability (restored to a low extinction risk), as well as at least 40 percent of each major life history type (e.g., summer-run and winter-run) historically present within each MPG achieve viability. There are no hatchery-origin steelhead produced in basin hatcheries that are included as part of the listed DPS.

Winter-run steelhead in the Snohomish River basin enter freshwater as adults between mid-October and May (Myers et al. 2015). Spawning occurs from mid-March through mid-June with peak spawning in April. Most winter-run steelhead return to spawn as four year-old (57%), and five year-old fish (42%) (PSSTRT 2013a citing WDFW 1994b). Juvenile out-migrant trapping data indicate that natural-origin Snohomish River basin steelhead juveniles emigrate seaward in April and May as smolts predominantly as two-year old fish (84%) and to a lesser extend three year old smolts (15%) (PSSTRT 2013a, citing WDFW 1994b).

Table 10. Naturally spawning steelhead abundances and trends for DIPs within the North Cascades MPG for which information is available. Populations within the Snohomish Basin are bolded. Note WR=winter-run, SUR=summer run, and SWR=summer/winter run population.

Population (Run Timing)	**2005-2009 Geometric Mean Escapement (Spawners)[1]**	**2010-2014 Geometric Mean Escapement (Spawners)[1]**	**Percent Change[1]**
Nooksack R WR	NA	1,834	NA
Pilchuck R WR	597	614	3%
Samish R WR	534	846	58%
Skagit R SWR[2]	4,767	5,123	7%
Snohomish/Skykomish WR	3,084[3]	930	-70%
Snoqualmie R. WR	1,249	680	-46%
Stillaguamish R. WR[4]	327	392	20%
Tolt River SUR	73	105	44%

1 Source: NWFSC 2015
2 Skagit data includes four DIPs: Skagit, Nookachamps, Baker, and Sauk.
3 Does not include return years 2007-2009, which were among the lowest abundance for Snohomish Basin populations.
4 Only includes the estimated number of naturally spawning steelhead in the North Fork Stillaguamish River index segments.

Adult summer steelhead return to the watershed between late-May and mid-October ((PSSTRT 2013a), predominately as four year olds. Summer-run steelhead in the Tolt River spawn from January through May, with two peak spawning periods in February and mid-April. Hatchery summer steelhead, the Skamania stock originating from the Columbia River, are reared at WDFW's Reiter Ponds and spawn from late-December through April. The spawn timing of the Columbia River Skamania lineage hatchery stock is believed to overlap with naturally-spawning native summer-run steelhead in the region, but the overlap may be diminished due to current broodstock collection procedures that have retained the earliest returning fish for spawning (Myers et al. 2015). However, recent genetic analyses conducted by WDFW indicate that introgression by Skamania-linage steelhead is substantial in at least two putative steelhead natural populations in the watershed (K. Warheit, WDFW, pers. comm., February, 2014). Summer-run steelhead are thought to exhibit the same predominantly 2-year smolt emigration life history strategy as natural-origin winter-run steelhead.

Historically, the Snohomish River basin was one of the primary producers of steelhead in Puget Sound (PSSTRT 2013a). Historical abundance estimates are lacking but steelhead harvest levels in basin fisheries in the late 1800s and early 1900s indicate that the numbers of steelhead were quite high. Harvests recorded for Snohomish County during these years were indicative of runs over 100,000 fish (PSSTRT 2013a). Escapement surveys by the Washington Department of Fish and Game in 1929 found large aggregations of steelhead in the Pilchuck, Sultan, Skykomish, and Tolt rivers, and medium aggregations in the North Fork and South Fork Skykomish, Wallace, Snoqualmie, and Raging rivers (Myers et al. 2015, citing WDFG 1932). Intrinsic potential (IP) production estimates indicate that the Snohomish River basin could support a total winter-run steelhead abundance for the three DIPs of approximately 43,322 fish (assumes a 10% SAS; Myers et al. 2015). Myers et al. (2015) estimated IP-based adult productivity capacity ranges from 21,389 to 42,779 adults for the Snohomish/Skykomish winter-run steelhead DIP; 5,193 to 10,386 adults for the Pilchuck River DIP; and 16,740 to 33,479 adults for the Snoqualmie River DIP. There are no estimates of annual steelhead smolt production for the basin. However, by comparison, the recent year (2000-2015) combined geometric mean escapement for the three winter-run populations in the Snohomish River basin is 3,066 fish (Marshall 2013) (see Figure 6), or 7.1% of the combined IP production capacity for the basin. Winter-run steelhead escapements have declined significantly since the mid-1990s (Ford et al. 2011; PSSTRT 2013b; Scott and Gill 2008). The TRT-derived interim DIP minimum abundance goals for the three winter-run populations are 10,695 for the Snohomish/Skykomish River population, 2,597 for the Pilchuck River winter-run population, and 8,370 for the Snoqualmie River winter-run population (Hard et al. 2015). The co-managers' upper management threshold for winter-run steelhead, reflecting the estimated escapement level that would optimally utilize available spawning and rearing habitat based on recent productivity and habitat conditions is 6,500 fish (or 15% of the combined low- IP production capacity for the basin).

The 5-year geometric mean abundance for the Snohomish/Skykomish population was 3,084 natural-spawners from 2005 through 2009 and only 930 from 2010 through 2014; indicating an overall decline of -70% (from Table 59 *in* NWFSC 2015). Hard et al. (2015) estimated that the probability that the population would decline to a QET of 73 steelhead was approximately 40% within 100 years; (see Table 9) based on a mean population growth rate of -0.005 (λ=0.995). The 5-year geometric mean abundance for the Pilchuck population was 597 natural-origin spawners from 2005 through 2009 and 614 from 2010 through 2014; indicating an overall increase of +3% (from Table 59 *in* NWFSC 2015). Hard et al. (2015) estimated that the probability that the population would decline to a QET of 34 steelhead was also approximately 40% within 100 years based on a mean population growth rate of -0.006 (λ=0.994). The 5-year geometric mean abundance for the Snoqualmie population was 1,249 natural-spawners from 2005 through 2009 and only 680 from 2010 through 2014; indicating an overall decline of -46% (from Table 59 *in* NWFSC 2015). Hard et al. (2015) estimated that the probability that the population would decline to a QET of 73 steelhead was approximately 70% within 100 years based on a mean population growth rate of -0.027 (λ=0.973).

The combined intrinsic potential for the two summer-run steelhead DIPs in the basin is 984 fish (assumes a 10% SAS; Myers et al. 2015). The IP capacity ranges for each summer-run steelhead DIP are 321 to 641 adults in the Tolt River DIP and 663 to 1,325 adults in the North Fork Skykomish River (Myers et al. 2015). For Tolt River summer-run steelhead (the only summer-run population in the basin for which redd count data are available), escapements have declined since the late 1990s. The recent year (2000-2015) average Tolt River summer-run steelhead escapement is 105 fish (WDFW Score

Database). The TRT minimum abundance goals for the two summer populations are 250 natural-origin fish for the Tolt River population and 331 for the North Fork Skykomish River natural population (Hard et al. 2015). The 5-year geometric mean abundance for the Tolt population was 73 natural-origin spawners from 2005 through 2009 and 105 from 2010 through 2014; indicating an overall increase of +44% (from Table 59 *in* NWFSC 2015). Hard et al. (2015) estimated that the probability that the population would decline to a QET of 25 steelhead was approximately 80% within 100 years (see Table 9); based on a mean population growth rate of -0.013 (λ=0.987).

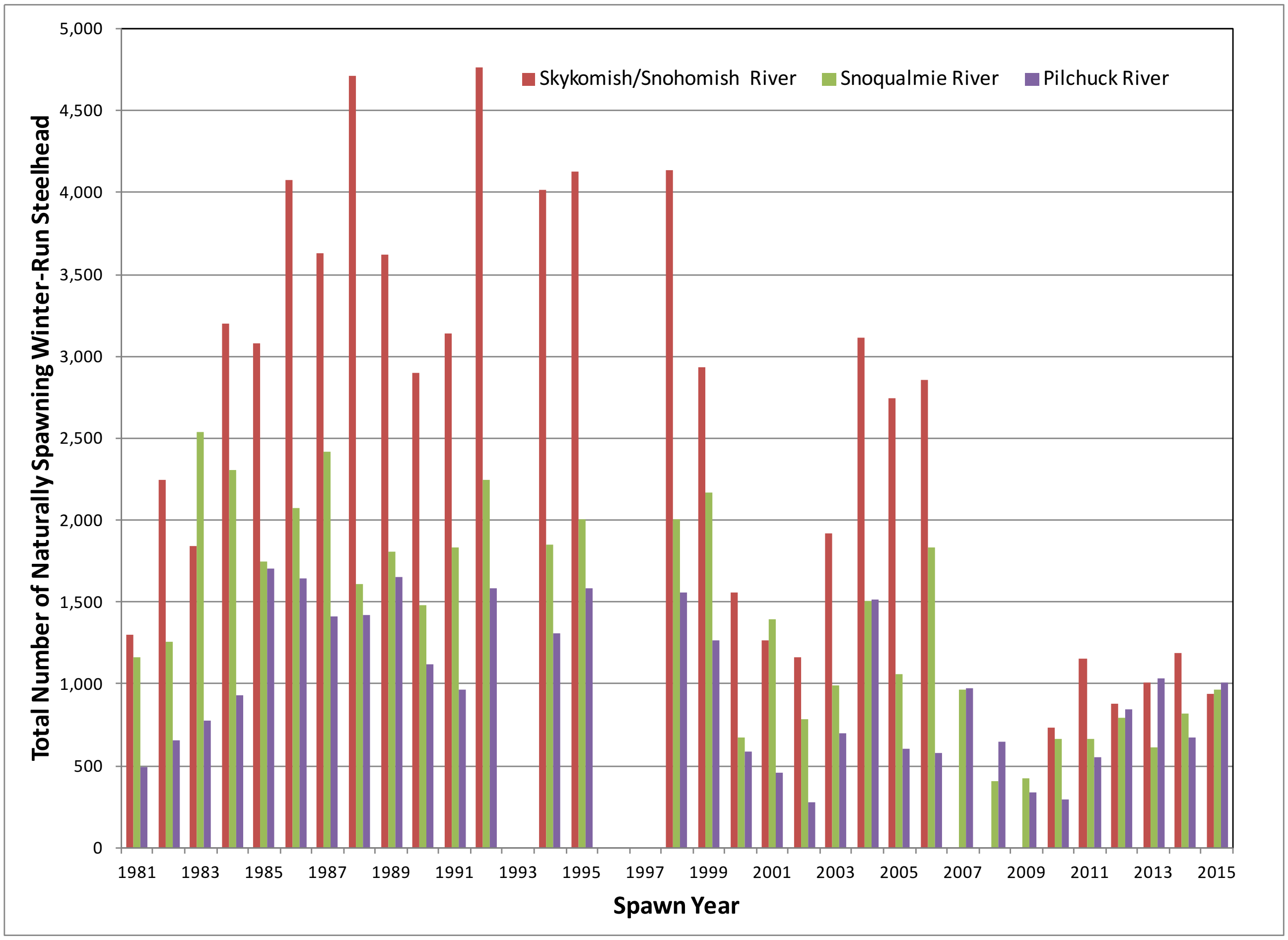

Figure 6: Total estimated number of naturally spawning winter-run steelhead based on post March 15th redd counts for the Skykomish, Snoqualmie, and Pilchuck rivers for return years 1981-2015. Source: WDFW Score Database. After March 15, natural spawners are most likely to be natural-origin fish.

Human developmental activities in the Snohomish River basin have adversely affected steelhead population spatial structure. Scott and Gill (2008) reported that the distribution of winter-run steelhead in the basin had been reduced from 0% to 23% (432 miles) from the historical distribution of 433 to 562 miles of riverine habitat. Similarly, the distribution of summer-run steelhead had been reduced from an historic distribution of 431 to 570 miles to a current distribution of 431 miles (up to a 24% reduction).

Data are not available to evaluate changes in the diversity of steelhead in the Snohomish River basin. However, it is likely that the degradation and loss of habitat in the watershed, and past harvest practices that disproportionately affected the earliest returning fish, have reduced the diversity of the species relative to historical levels. Genetic diversity of the winter-run natural populations has likely been adversely affected by releases of non-native early-winter steelhead from basin hatcheries, in watershed areas where spawn timings for natural and hatchery-origin fish have over-lapped. Hatchery introduction of summer-run steelhead of Columbia River Skamania-origin into the South Fork Skykomish River coincident with the initiation of a trap-and-haul operation at Sunset Falls in the mid-1950s has likely reduced the diversity of the summer-run race the watershed. The introduction resulted in a self-sustaining population with genetic characteristics that differ from the native North Fork Skykomish population (Kassler et al. 2008). This introduced population, and continued releases of Skamania lineage steelhead through the WDFW Reiter Ponds program, have affected the genetic diversity of native summer-run steelhead in the watershed through genetic introgression (Warheit 2014).

2.2.2.2 Status of Critical Habitat for Puget Sound Steelhead

Critical habitat has been designated for Puget Sound steelhead (81 FR 9252, February 24, 2016). Designated critical habitat for the Puget Sound steelhead DPS includes specific river reaches associated with the following subbasins: Strait of Georgia, Nooksack, Upper Skagit, Sauk, Lower Skagit, Stillaguamish, Skykomish, Snoqualmie, Snohomish, Lake Washington, Duwamish, Puyallup, Nisqually, Deschutes, Skokomish, Hood Canal, Kitsap, and Dungeness/Elwha. The designation does not include specific areas in the nearshore zone in Puget Sound or offshore marine areas. Steelhead move rapidly out of freshwater and into offshore marine areas, unlike other salmonid species such as Puget Sound Chinook and Hood Canal summer chum. . There are 18 subbasins (HUC4 basins) containing 66 occupied watersheds (HUC5 basins) within the range of this DPS. Nine watersheds received a low conservation value rating, 16 received a medium rating, and 41 received a high rating to the DPS (78 FR 2726, January 14, 2013). Of the nine watersheds within the Snohomish system (Skykomish River Forks, Skykomish River/Wallace River, Sultan River, Skykomish River/Woods Creek, Tye and Beckler Rivers, Pilchuck River, Snohomish River, Lower Snoqualmie River, and Middle Fork Snoqualmie River), seven received high and two received medium conservation value ratings.

NMFS determines the range-wide status of critical habitat by examining the condition of its physical and biological features (also called "primary constituent elements," or PCEs, in some designations) that were identified when the critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). In the proposed rule for Puget Sound steelhead (78 FR 2726, January 14, 2013), PCEs for the Snohomish populations included:

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

(2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging

large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

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

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

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

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

Critical habitat is designated for Puget Sound steelhead in the Snohomish River within the action area. Critical habitat includes the stream channels within the Basin, and includes a lateral extent as defined by the ordinary high-water line (33 CFR 319.11). The Puget Sound Critical Habitat Analytical Review Team CHART) identified management activities that may affect the PCEs within the action area (NMFS 2013). These activities included agriculture, grazing, irrigation impoundments and withdrawals, channel modifications/diking, dams, forestry, urbanization, sand/gravel mining, wetland loss/removal, and road building/maintenance (81 FR 9252, February 24, 2016).

The Puget Sound CHART found that habitat utilization by steelhead in a number of Puget Sound areas has been substantially affected by large dams and other manmade barriers in a number of drainages (this and following from NMFS 2013). Affected areas include the Nooksack, Skagit, White, Nisqually, Skokomish, and Elwha river basins. In addition to limiting habitat accessibility, dams have affected steelhead habitat quality through changes in river hydrology, altered temperature profile, reduced downstream gravel recruitment, and the reduced recruitment of large woody debris. In addition, many upper tributaries in the Puget Sound region have been affected by poor forestry practices, while many of the lower reaches of rivers and their tributaries have been altered by agriculture and urban development. Urbanization has caused direct loss of riparian vegetation and soils, significantly altered hydrologic and erosional rates and processes (e.g., by creating impermeable surfaces such as roads, buildings, parking lots, sidewalks etc.), and polluted waterways with storm-water and point-source discharges. The loss of wetland and riparian habitat has dramatically changed the hydrology of many streams all to the detriment of steelhead habitat, with increases in flood frequency and peak flow during storm events and decreases in groundwater driven summer flows. River braiding and sinuosity have been reduced through the construction of dikes, hardening of banks with riprap, and channelization of the mainstem rivers. These actions have led to constriction of river flows, particularly during high flow events, increasing the likelihood of gravel scour and the dislocation of rearing juvenile steelhead. The loss of side-channel habitats has also reduced important areas for spawning, juvenile rearing, and overwintering habitats.

Estuarine areas have been dredged and filled, resulting in the loss of important juvenile steelhead rearing areas.

In addition to being a factor that contributed to the present decline of Puget Sound steelhead natural populations, the continued destruction and modification of steelhead habitat is the principal factor limiting the viability of the Puget Sound steelhead DPS into the foreseeable future (NMFS 2013). Because of their limited distribution in upper tributaries, summer-run steelhead may be at higher risk than winter-run steelhead from habitat degradation in larger, more complex watersheds.

2.2.3 Climate Change

Climate change has negative implications for designated critical habitats in the Pacific Northwest (CIG 2004; ISAB 2007a; Scheuerell and Williams 2005; Zabel et al. 2006). The distribution and productivity of salmonid populations in the region are likely to be affected (Beechie et al. 2006). Average annual Northwest air temperatures have increased by approximately 1ºC since 1900, or about 50% more than the global average over the same period (ISAB 2007a). 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 stream-flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures. As climate change progresses and stream temperatures warm, thermal refugia will be essential to persistence of many salmonid populations. Thermal refugia are important for providing salmon and steelhead with patches of suitable habitat while allowing them to undertake migrations through or to make foraging forays into areas with greater than optimal temperatures. To avoid waters above summer maximum temperatures, juvenile rearing may be increasingly found only in the confluence of colder tributaries or other areas of cold water refugia (Mantua et al. 2009).

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Within the Snohomish River basin, precipitation is not evenly distributed throughout the watershed, primarily due to the Cascade Mountains; precipitation ranges from 35 inches per year near Possession Sound to 180 inches per year near Mount Hinman and Mount Daniel (Haring 2002 citing Gersib 1999). The Snohomish, Skykomish, and Snoqualmie rivers all include significant portions of their watershed area in high elevation zones which contribute to their two distinct periods of high monthly flows. The highest average monthly streamflows occur from November through January, and again in May and June (USGS stream gage records for gage 12150800 and following). The high monthly streamflows in May and June are a result of melting snow and warming spring air temperatures.

In general, peak flows are not associated with spring snow melt and occur during intense rain events or rain-on-snow events. Within the Snohomish River, 70-percent of annual peak stream flows occur from November through January. The lowest flows occur in August and September.

Since climate change would likely reduce snowpack, run-off from snow melt in spring and summer would be reduced, and associated factors (e.g., re-channeling of the river bed, movement of silt out of the system, transport of woody debris) would be affected. Battin et al. (2007) found that the greatest threats from climate change to Snohomish basin Chinook salmon were associated with projected increases in peak flows. Battin et al. (2007) projected that the greatest, most severe impacts from climate change would occur in the higher elevation subbasins. For these reasons, Battin et al. (2007) suggested that the most practical restoration actions for Chinook salmon should focus on lower elevation floodplains. 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 2007a).

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

2.3 Environmental Baseline

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.”

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

A variety of human activities have affected ESA-listed Chinook salmon and steelhead populations and the species' PCEs in the action area. Historical and on-going activities in the freshwater and marine environment have resulted in the degradation and loss of habitat sustaining ESA-listed fish species, and important for their short and long-term survival (Section 2.3.1). Fisheries have historically impacted the abundance of Chinook salmon and steelhead escaping to spawn in the action area (Section 2.3.2). The operation of hatcheries to produce fish for harvest has impacted the viability status of Snohomish River basin salmon and steelhead populations (Section 2.3.3). More recently, habitat restoration actions have been included that are having beneficial effects on fish habitat (Section 2.3.4). Essential for considering environmental baseline effects on ESA-listed Chinook salmon and steelhead is how the habitat, harvest, and hatchery ("All H") activities described under the Environmental Baseline interact in determining the status of ESA-listed fish populations. This section therefore includes a discussion of how "All H" activities will be harmonized in considering effects of the proposed action in this opinion (Section 2.3.5).

2.3.1 Habitat

At 1,856 square miles in area, the Snohomish River basin is the second largest watershed draining to Puget Sound (SBSRTC 1999). The Snohomish River is formed by the confluence of the Skykomish and Snoqualmie rivers. Numerous tributaries enter the Snohomish River mainstem, with the largest being the Pilchuck River. Over 1,730 tributary rivers and streams have been identified in the basin, totaling approximately 2,718 miles in length (Williams et al. 1975). The Snohomish River basin is the major source of municipal water supply for Everett and southwest Snohomish County, and it contributes to water supplies in Seattle, Bellevue, and King County.

Forest lands or wilderness comprise approximately 75 percent of the Snohomish River basin which contributes to greater hydrologic and riparian function and better sediment conditions than are found in other basins across Puget Sound (SSPS 2005). Approximately 50 percent of forest lands within the basin are in federal ownership. Much of this federal land is contained within designated wilderness, and the remainder is managed under the Northwest Forest Plan that limits most activities to restoration. Although forest practice impacts on private and state-managed forest lands within the action area are limited by federally approved habitat conservation plans (HCPs), degradation and fragmentation of freshwater habitat from forest practice activities, with consequent effects on connectivity, are primary limiting factors and threats affecting salmon and steelhead natural populations in the Snohomish River basin.

One primary habitat loss-related limiting factor in the action area has been the loss or impairment of floodplain function. Much of the historical salmon production capacity in the Snohomish River basin was associated with the presence of abundant floodplain and estuarine wetlands. Relative to historical levels, Bortelson et al. (1980) reported a 74% reduction in floodplain wetlands, and a 32% loss of intertidal wetlands for the Snohomish River. Settlers drained and/or isolated approximately 3,370 hectares of palustrine marsh in the Snohomish River floodplain upstream of Ebey Slough (Haas and Collins 2001, and following). Diking and bank armoring over the past century contributed to a 2-kilometer decrease in total length of side channels and a 55% reduction in the area of side channel sloughs on the Snohomish River. There has also been a 40% loss of beaver pond areas that function to moderate high flows, serve as fish refugia during low flows, and provide important salmon rearing areas. Extensive historical floodplain wetlands at Marshland and lower French Creek have been diked and drained, and no longer provide salmonid habitat. Estimates of lost natural Chinook and coho salmon production capacity associated with the historical loss of floodplain habitat are 40-61% and 50%, respectively (Haas and Collins 2001).

Another primary limiting factor is the degradation and loss of nearshore, estuary, mainstem river and key tributary salmon and steelhead habitats that have been adversely affected, or are threatened, by a number of activities (SSPS 2005). Approximately 70 percent of the Snohomish River basin nearshore shoreline has experienced significant modification and subsequent population declines in plant and animal species important for various salmon life stages (SBSRF 2005). Riparian conditions, intertidal habitat conditions, and sediment delivery, transport, and storage have been extensively modified along the Snohomish nearshore, most notably due to construction of the Burlington Northern/Santa Fe railroad in the 1890s, construction of bulkheads, riprap, and piers in the industrial waterfront, and dredging of berths and the federal navigation channel (SBSRF 2005). The most significant habitat impacts in the nearshore result from the railroad and from shoreline armoring. The largest threat to habitat facing the estuary is urbanization downstream of Interstate-5. Permanent habitat losses have already occurred and few sites remain undeveloped. Agricultural uses dominate the floodplain and account for 5 percent of the basin area (SBSRTC 1999). Dikes and water control structures associated with these activities exist throughout the estuary which limits the aquatic habitat accessible by fish and has reduced salmon rearing habitat in the lower mainstem and estuary by over 70 percent (SBSRTC 1999). Some re-establishment of tidal influence has occurred since the late 1980's due to intentional and natural breaching of some dikes in the estuary, leading to improvements in salmon habitat in the area.

Dikes, bank armoring, roads, railroads, and bridges confine the mainstem Snohomish, Skykomish, and South Fork Skykomish Rivers, disconnect off-channel habitat, reduce edge habitat complexity, and increase peak flows downstream. Riparian forest cover has been substantially degraded within these areas, reducing large woody debris recruitment to the waterways and further simplifying the habitat. Other habitat problems in the mainstem rivers include excessive erosion of stream banks, culverts that restrict or completely block fish access to streams, and degraded water quality, high water temperature, (summer river temperatures that lead to migration delay or blockage (at or above 20 degrees C. [Goniea et al. 2006]), and exceeding levels lethal to adult Chinook salmon (in excess of 22 degrees C. [Richter and Kolmes 2005]), low dissolved oxygen, high fecal coliform counts, and high levels of toxic metals).

The Skykomish River originates in the Cascade Mountains. The upper Skykomish River mainstem has a steep gradient, transporting sediment quickly through confined channels (SBSRF 2005). As the river gradient decreases downstream of Gold Bar, gravel and cobble settle out, forming multiple channels and excellent spawning riffles and rearing habitat (SBSRF 2005). In the lower reaches, the river banks in many places are armored and this blocks access to side-channel rearing habitat (this and following from SBSRTC 1999). Forestry comprises 50% of the land base in the mainstem-primary restoration group (SBSRF 2005). Forestry is most dominant in the highest elevation areas, including the Upper North Fork Skykomish and South Fork Skykomish watershed upstream of Sunset Falls (SBSRF 2005).

Logging road failures in the upper basins has resulted in channel destabilization and sedimentation which has degraded the quality of salmon and steelhead spawning habitat (SBSRTC 1999). Approximately 30% of land use in the mainstem-primary restoration group is currently in residential development (SBSRF 2005). Residential land uses are, for the most part, located away from the river shorelines, which are zoned primarily for agricultural production (SBSRF 2005). Pockets of rural residential development occur directly adjacent to mainstem river reaches near several small cities (SBSRF 2005).

Two types of hydroelectric operations are present in the Snohomish River basin: storage facilities and run-of-the-river facilities. The Henry M. Jackson and the South Fork Tolt River hydroelectric projects are both storage facilities. Bedload transport (quantity and quality) and water level drawdowns are both on-going issues with the Jackson facility, which is located on the Sultan River, a tributary to the lower Skykomish River. The remaining projects in the basin are run-of the- river operations with little or no storage, and they are all upstream of natural barriers to anadromous fish migration (SBSRTC 1999).

The Snohomish Basin is one of the fastest growing areas in the Puget Sound region and the human population is projected to increase by 59 percent from 311,224 in 2000 to 528,293 in 2030 (SSPS 2005). Population growth within and adjacent to the Snohomish River basin will result in increased demand for basin water. It is estimated that approximately 1.4 million people will be dependent upon water withdrawals from the basin by 2020 resulting in an increased withdrawal of 53 million gallons per day (SBSRTC 1999 citing Pentec 1998). The areas that will experience the greatest population pressures are along the mainstem rivers and lowland tributaries as forest cover and ecosystem processes are altered or lost when these lands are converted to residential and urban areas,.

2.3.2 Harvest

Hatchery-origin Chinook salmon produced through the WDFW and Tulalip tribal programs are subject to directed harvest in terminal area net fisheries in marine waters, and recreational fisheries in marine waters, the Snohomish River, and the Skykomish River. The Tulalip Terminal Area Fishery (Commercial Catch Reporting Area 8D, or for recreational fisheries, the Tulalip Bay “bubble” area) is the primary terminal marine area where hatchery-origin Chinook salmon produced through the Tulalip Hatchery program are harvested, with an annual average of 5,749 fish harvested in tribal net fisheries (1988-2011) and 1,145 fish harvested in recreational fisheries (1994-2010) (Tulalip 2012). There is currently no fishery (tribal, commercial or recreational) that targets natural-origin Skykomish or Snoqualmie Chinook salmon. However, natural-origin Chinook salmon from the two populations are harvested (limited to certain time, gear, and area fisheries) or impacted incidentally in fisheries directed at hatchery-origin Chinook and coho salmon. Harvest of basin-origin natural and hatchery-origin Chinook salmon occurs in mixed stock marine area fisheries in U.S. and Canadian waters. Exploitation rates on Skykomish and Snoqualmie natural-origin populations were nearly 80 percent for brood years 1980 through 1985, contributing to the observed decline in numbers of fish returning to the spawning grounds (PSIT and WDFW 2010a). However, harvest impacts on natural-origin Chinook salmon produced in the Basin have been substantially reduced over the last few decades (SSPS 2005).

Fishery impact modeling by the co-managers shows a declining trend in annual fishing year exploitation rate from 1983-2000, and fairly stable rates since 2000 (PSIT and WDFW 2010). Declining from an annual average of 70 percent in the 1980s, exploitation rates from 2003 through 2010 on natural-origin Chinook salmon from the Snohomish River basin have ranged from 21 to 34 percent; averaging 28 percent (PSIT and WDFW 2013). These impacts occur incidentally in terminal area fisheries targeting hatchery-origin Chinook and coho salmon, and in pre-terminal marine area mixed-stock fisheries. The goal of harvest management is to maintain rebuilding exploitation rates low enough (24 percent) so that natural-origin Chinook salmon escape in increasing numbers to spawn in protected or restored habitat. Prior to the Tulalip Tribes' development of an extreme terminal area fishery targeting hatchery-origin fish, the Tribes' harvest was composed of 50-60 percent natural-origin Chinook salmon. The Tribes' combined natural-origin Chinook salmon harvest during the past 20 years in Areas 8A and 8D have averaged less than 5 percent (Tulalip Tribes, unpublished Chinook salmon harvest data).

Within the action area, Tulalip tribal commercial and ceremonial and subsistence fisheries for primarily hatchery-origin salmon and steelhead occur seasonally in Everett Bay, Port Susan, Tulalip Bay, and in the lower Snohomish River, contingent on the availability of fish surplus to escapement needs. WDFW-managed non-tribal commercial fisheries in commercial harvest areas 8A and 8D target surplus returning coho, fall chum, and pink salmon. Between 2005 and 2014, annual tribal and all citizen net fishery harvests of coho salmon in the analysis area averaged 34,600 and 500, respectively (WDFW 2015a, and following). Between 2005 and 2013, odd-year tribal and all citizen net fishery harvests of pink salmon averaged 154,100 and 244,200, respectively. Between 2005 and 2014, annual tribal and all citizen net fishery harvests of fall-run chum salmon averaged 41,700 and 20,800, respectively.

Recreational fisheries for salmon managed by WDFW occur in the Snohomish, Skykomish, Wallace, and Snoqualmie rivers. Regulations vary by time, area, and species contingent on the availability of fish surplus to escapement needs. Annual recreational fisheries from 2000-2015 averaged 3,888, 1,471, and 382 coho salmon harvested in the Snohomish, Skykomish, and Snoqualmie river basins, respectively (WDFW 2005; WDFW 2008; WDFW 2010a; WDFW 2010b; WDFW 2011a; WDFW 2011b; WDFW 2011c; WDFW 2011d; WDFW 2012; WDFW 2013d; WDFW 2014a; WDFW 2014b; WDFW 2015b, WDFW 2016; WDFW 2017 and following). Annual recreational fisheries from 2000-2015 averaged 20,222, 3,936, and 588 pink salmon harvested in the Snohomish, Skykomish, and Snoqualmie river basins, respectively. Odd year harvests of pink in the same three watersheds averaged 44,312, 7,871, and 1,176. Annual recreational fisheries from 2000-2015 averaged 209 and 1 Chinook salmon harvested in the Skykomish and Snohomish river basins, respectively (current sport harvest regulations limit Chinook salmon harvest to 1 or 2 adult hatchery Chinook salmon per day on only the Skykomish River [downstream of the Wallace River] in the months of June and July). Annual recreational fisheries from 2000-2015 averaged 224, 209, and 13 chum salmon harvested in the Snohomish, Skykomish, and Snoqualmie river basins, respectively.

Within the action area, Tulalip tribal commercial and ceremonial and subsistence fisheries for primarily hatchery-origin steelhead occur seasonally in Everett Bay, Port Susan, Tulalip Bay, and in the lower Snohomish River, contingent on the availability of fish surplus to escapement needs. Non-Indian commercial fishing is closed to steelhead in all areas, although there is some incidental harvest mortality in salmon-directed fisheries. Recreational fisheries for salmon and unlisted steelhead managed by WDFW occur in the Snohomish River, Snoqualmie River, Skykomish River, and select tributaries. Between 2000 and 2012, annual tribal and non-Indian fishery harvests of non-listed early winter steelhead (EWS) in the analysis area averaged 95 and 4,482 fish, respectively (WDFW 2014a). During this same period, recreational fisheries harvest of non-listed Columbia River origin Skamania early summer steelhead (ESS) averaged 2,895 fish per year.

2.3.3 Hatcheries

Another aspect of the Environmental Baseline is hatchery effects – effects from hatchery programs located in the Snohomish Basin (Section 2.4.2) and from fish that stray into the Snohomish Basin from programs outside the basin.

The Snohomish salmon hatchery programs were initiated because habitat in the Snohomish basin had been degraded or lost altogether and could no longer provide fish for harvest. WDFW's Wallace River Hatchery summer Chinook salmon hatchery program was initiated in 1972, and the Tulalip Bay Hatchery program propagating summer-run Chinook salmon stock transferred from the WDFW hatchery commenced in 1998. Coho salmon have been released from Wallace River Hatchery since the 1920s, and releases of the species from Tulalip Hatchery began in 1981. A non-native stock-origin fall chum salmon program using stock transferred from Hood Canal and (later) deep South Puget Sound was initiated through fry releases in Tulalip Bay beginning in 1976. Located near the mouth of the Snohomish River in the Port of Everett Marina (Port Gardner Bay), the Everett Bay Net-Pen coho salmon program was initiated in 2001 to provide recreational fishing opportunity in the Everett Bay area.

In the context of the environmental baseline, there are pros and cons, benefits and risks from the operation of hatchery programs and the general types of hatchery-related effects, from beneficial to negative, are identified in Section 2.4.1. For this analysis, the specific effects of hatchery programs on the environmental baseline are described below.

The Wallace River Hatchery Chinook salmon program has likely affected the diversity, spatial structure, and productivity of the Chinook salmon natural population. First or subsequent generation hatchery Chinook salmon are known to spawn in the Snohomish River watershed and it is reasonable to expect that spawning by these fish has had some effect on the genetic diversity and fitness of the aggregate Skykomish natural population and on the Snoqualmie natural population. There is no direct measure of this effect, and best management practices have been implemented, when it comes to broodstock collection, selection, mating, rearing, and juvenile release strategies to limit demographic (e.g., mining), genetic and ecological effects on both of the Chinook salmon natural populations in the Snohomish watershed. In the Wallace River, Chinook salmon have been passed upstream of the Wallace River weir to seed natural habitat with naturally spawning fish, and migration and blockage effects that weirs can have are minor.

Although produced for fisheries harvest augmentation purposes, some Chinook salmon produced by the two hatchery programs inevitably escape the fisheries and end up spawning naturally. The donor broodstock source for the WDFW and Tulalip hatchery programs is the Skykomish Chinook salmon natural population, and care has been taken to minimize genetic divergence from that source stock while under propagation in the hatcheries. Because of the origin of the hatchery stock, and measures applied in the hatcheries to minimize genetic divergence from the natural population, the programs may have benefited the abundance and spatial structure of the Skykomish Chinook salmon population when the adults escaped into natural spawning areas. Another beneficial effect is the contribution hatchery fish make to the productivity of salmon and steelhead rearing areas. The carcasses of naturally spawning hatchery-origin salmon and spawned broodstock originating from the hatchery programs have no doubt contributed important marine derived nutrients to the watershed, and thus, have likely benefited ESA-listed natural populations.

Because of species differences that prevent hybridization in the wild, none of the Chinook salmon, fall chum salmon, and coho salmon programs have affected the genetic diversity status of ESA-listed steelhead populations in the action area. However, genetic analyses of Snohomish River basin steelhead indicate that adult fish produced by the two EWS programs in the action area, and by the Reiter Ponds early ESS program, have interbred with natural-origin steelhead (Warheit 2014).

Steelhead hatchery programs in Puget Sound were initiated beginning in the early 1900s. In 1935, steelhead returning to Chambers Creek were used to establish a hatchery stock that was subsequently released throughout much of Puget Sound (Crawford 1979), including in the Skykomish and Snoqualmie river basins (1960s; WDFW 2014a; 2014b). During the 1960s, advances in hatchery cultural techniques led to further development of the Chambers Creek (aka "Early Winter") hatchery-origin stock through broodstock selection and accelerated rearing practices (Crawford 1979). The earliest maturing adult steelhead were selected in order to produce fish that smolted at one year of age, rather than, at age-2 or older as normally occurs in the wild (WDFW 2005a). The Snohomish basin programs began collecting hatchery broodstock in the early-1960s (WDFW 2014a; 2014b, and following). From the late-1970s to late-1990s, the Snohomish River basin EWS released at all sites in the basin were propagated from adult returns to Tokul Creek (and Whitehorse Ponds when insufficient broodstock was available). Prior to 1994, eggs collected at Tokul Creek were incubated to the eyed stage on-site and transferred to Lakewood Hatchery for further incubation, rearing, and mass-marking subsequent to dispersal of juvenile EWS for rearing and release in other Puget Sound areas, including the Snohomish Basin. The current goal for the Snohomish River basin EWS program is to manage the two programs separately. Beginning in 2015, broodstock for the Wallace/Reiter EWS program have been maintained primarily through collection of adults returning to Wallace River Hatchery and Reiter Ponds.

No genetic data for Puget Sound steelhead are available that reflect the patterns of genetic diversity among Puget Sound steelhead populations before the EWS programs began (NMFS 2016b). NMFS believes it is likely that these patterns have been altered by returning EWS spawning in the wild with naturally produced winter steelhead, but the cumulative impact of the EWS programs on genetic diversity and fitness is unknown. The genetic markers currently used to assess population structure cannot differentiate Chambers Creek stock from other Puget Sound steelhead populations but genetic introgression has likely occurred between populations of hatchery and natural-origin fish for decades reducing the genetic diversity necessary to distinguish populations. In its biological opinion addressing effects of WDFW's EWS programs on listed natural steelhead in the Snohomish River basin, NMFS determined that the programs will have negative effects on ESA-listed steelhead but they will not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the Puget Sound steelhead DPS (NMFS 2016b).

The production and release of hatchery-origin Columbia River Skamania stock lineage early summer steelhead (ESS) into the Snohomish basin has negatively affected the abundance, diversity, spatial structure, and productivity of natural winter and summer steelhead populations (NMFS 2016b). ESS returns in Puget Sound, derived approximately 40 years ago from transplanted Columbia River basin

Washougal and Klickitat stock, were similarly developed through hatchery release programs in the Stillaguamish, Snohomish, and Green River watersheds. Self-sustaining broodstock returns have been maintained in Stillaguamish River watershed hatcheries for about 30 years (WDFW 2005a). Hatchery smolts from these cultured stocks, released at a size of 5 to 6 fish per pound (198 – 210 mm fl), have been shown to emigrate quickly seaward after release, and survive well to adult return. ESS are thought to spawn somewhat earlier than summer steelhead natural populations in Puget Sound (Myers et al. 2015 citing Campbell et al. 2008), with spawn timing analyses suggesting peak spawning activity for ESS in February, and peak spawning for steelhead from natural-origin populations in mid-April. While the genetic profile of the Chambers Creek EWS stock is too similar to the other Puget Sound steelhead populations to be able to assess cumulative gene flow effects, more can be said in the case of releases of ESS because of their Columbia Basin origin. WDFW estimates that impacts to two summer steelhead populations in the Snohomish Basin have been so large that they are now considered feral populations of Skamania-stock fish (Warheit 2014).

The six salmon hatchery programs, two non-listed, early winter steelhead hatchery programs, and one summer-run hatchery program operating within the action area, may have adversely affected listed Chinook salmon and steelhead through ecological effects, including predation on emigrating and rearing juvenile Chinook salmon by hatchery yearling Chinook and coho salmon, and steelhead in the Skykomish, Snoqualmie, and Snohomish rivers, downstream of release locations (e.g., Wallace River Hatchery, Tokul Creek Hatchery, and the Reiter Ponds facility [NMFS 2016b]). The timing of hatchery yearling releases has coincided with the out-migration timing of natural-origin Chinook salmon of an average size vulnerable to predation. The magnitude of predation effects is unknown. Natural-origin juvenile steelhead of sizes vulnerable to predation by the hatchery yearlings emerge from redds later in the season, and are unlikely to be encountered or preyed upon. Subyearling Chinook salmon produced through the Wallace River Hatchery program have been released in May or June, after the majority of natural-origin Chinook salmon have emigrated seaward. No or minimal predation effects have likely occurred as a result of subyearling hatchery Chinook salmon releases. None of the hatchery-origin species produced in the action area are likely to have competed with natural-origin Chinook salmon and steelhead at substantial levels for food or space. All hatchery salmon and steelhead are released as smolts that will quickly emigrate seaward. For these reasons, the duration of, and opportunities for, interactions that would lead to competition with ESA-listed juvenile fish have been limited.

Wallace River hatchery facility operations may have adversely affected the viability status of natural-origin salmon and steelhead populations in the action area. A full river-spanning weir has been operated at the Wallace River Hatchery on the mainstem Wallace River and in May Creek. The weirs seasonally block Chinook salmon access to upstream spawning areas. The May Creek weir has blocked salmonid access to upstream areas during summer and fall for several decades, to enable the withdrawal of water for use in the Wallace River Hatchery, as well as to capture potential broodstock. The Wallace River weir is placed and operated from June through September each year. The May Creek weir is operated from June through mid-December.

The effects of Chinook salmon hatchery programs outside of the Snohomish watershed on the two listed Snohomish River Chinook salmon natural populations are unknown. The closest hatchery programs are located in the Stillaguamish River. Juvenile and adult Chinook salmon from the Stillaguamish River are known to co-occur with Snohomish River Chinook salmon (Tulalip 2012), and it is likely that there have been interactions, although the degree to which these interactions have occurred and the effects from any interactions are unknown. Available data (see Section 2.4.2.2) indicate that Stillaguamish hatchery-origin Chinook salmon, as well as other Puget Sound hatchery-origin Chinook salmon, stray into the Snohomish River basin but the degree or level of straying is not entirely clear. Measures have been implemented to allow monitoring of out-of-basin origin fish straying into the Snohomish River watershed, including mass marking of all hatchery-fish release groups (including adipose fin clips, CWTs, and otolith thermal marks). Among-population diversity reduction risks associated with out-of-basin hatchery salmon straying into the Snohomish River could be substantial if assumptions of moderate levels of straying based on available information remain correct.

2.3.4 Habitat Restoration and Recovery Activities

The Pacific Coastal Salmon Recovery Fund (PCSRF) was established by Congress to help protect and recover salmon and steelhead populations and their habitats (NMFS 2007). The states of Washington, Oregon, California, Idaho, and Alaska, and the Puget Sound, Pacific Coastal, and Columbia River Basin 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. In addition, other federal, state, tribal, local, and private funding sources support recovery planning and on-the-ground restoration activities throughout the regions.

Over the last several years, NMFS has completed several section 7 consultations on large scale habitat projects affecting listed species in Puget Sound. Among these are the Washington State Forest Practices Habitat Conservation Plan (NMFS 2006a), and consultations on Washington State Water Quality Standards (NMFS 2008a) and the National Flood Plain Insurance Program (NMFS 2008b). These documents encompassed the effects of the proposed habitat effect actions that would occur up to the next 50 years on the ESA listed salmon and steelhead species in the Puget Sound basin. The environmental baselines in these documents consider the effects from timber, agriculture and irrigation practices, urbanization, hatcheries and tributary habitat, estuary, and large scale environmental variation. These biological opinions and HCPs, in addition to the watershed specific information in the Puget Sound Salmon Recovery Plan mentioned above, provide a current and comprehensive overview of baseline habitat conditions in Puget Sound. The portions of those documents that deal with effects in the action area (described in Section 2.4) are hereby incorporated by reference.

The federally approved Shared Strategy for Puget Sound Recovery Plan for Puget Sound Chinook Salmon (SSPS 2005b), Volume II of the plan (SSPS 2005a), and the Snohomish River Basin Salmon Conservation Plan (SBSRF 2005) describe, in detail, on-going and proposed state, tribal, and local government restoration and recovery activities for listed Chinook salmon in the Snohomish River basin. The Snohomish Basin Salmon Conservation Plan (SBSRF) was prepared by the 41-member Snohomish Basin Salmon Recovery Forum, which updates the recovery work plan annually through 3-year work plan updates. Snohomish River basin habitat restoration activities are also guided by the State of Our Watersheds report, that examines key indicators of habitat quality and quantity within the Tulalip Tribes' usual and accustomed fishing area (accessible at: http://maps.nwifc.org:8080/sow2012/). Many of the projects currently being implemented in the Snohomish River basin are funded through the PCSRF. Tribal, state, and local government fish restoration actions include legislation, administrative rules, policy initiatives, and land use and other types of permits. Government and private actions may also include changes in land and water uses, including ownership and intensity, which could affect listed species or their habitat.

These planning documents provide a long-, medium-, and short-term roadmap to needed restoration and recovery actions throughout the watershed prioritized at both the sub-basin and reach scales. Habitat protection and restoration actions implemented thus far in the Snohomish River basin have focused on preservation of existing habitat and habitat-forming processes; protection of nearshore environments, including estuaries and marine shorelines; instream flow protection and enhancement; and reduction of forest practice and farming impacts to salmon habitat. The Snohomish Plan (SBSRF 2005) established 10-year benchmark habitat restoration and protection goals for the following habitat types: nearshore and beaches, estuary and tidal marshes, primary mainstem habitats, secondary mainstem habitats, primary rural streams, secondary rural streams, and urban streams. The 2014 three-work plan update (SBSRF 2014 and following) compared recovery progress through early-2014 to the 10-year bench mark goals for recovery actions and found the following:

- Nearshore beaches: Goal- restore at least 1 mile of habitat, accomplishments- 0.39 miles of restored habitat since 2005.
- Estuary and tidal marshes: Goal- restore 1,237 acres of habitat, accomplishments- 460.6 acres restored since 2005 and active projects (Qwuloolt and Smith Island) which will restore an additional 780 acres of habitat by 2016.
- Primary mainstem habitats: Goal 1- restore at least 10.4 miles of edge habitat, accomplishments- 2.9 miles restored since 2005; Goal 2- restore 256 acres of riparian habitat, accomplishments- 191 acres of riparian habitat restored since 2005; Goal 3- restore 167 acres of off-channel habitat, accomplishments- restored 31.3 acres of habitat since 2005; Goal 4- add 41 logjams, accomplishments- constructed 6 functional logjams since 2005.
- Secondary mainstem habitats: Goal 1- restore 6 acres of riparian habitat, accomplishments- no accomplishments made; Goal 2- restore 6 acres of off-channel habitat, accomplishments- no accomplishments made.
- Primary rural streams: Goal 1- restore 13 acres of riparian habitat, accomplishments- 6 acres of riparian habitat restored since 2005; Goal 2- restore 10 acres of off-channel habitat, accomplishments- 5 acres of off-channel habitat have been restored since 2005.
- Secondary rural streams: Goal 1- restore 0 acres of riparian habitat, accomplishments- 13 acres of riparian habitat restored since 2005; Goal 2- restore 41 acres of off-channel habitat, accomplishments- 7 acres of off-channel habitat have been restored since 2005.
- Urban streams: Goal- restore at least 75 acres of riparian habitat, accomplishments- 26 acres of riparian habitat restored since 2005.

Specific actions to recover listed salmon and steelhead have included: implementation of land use regulations to protect existing habitat and habitat-forming processes through updating and adopting Federal, state, and local land use protection programs, as well as more effectively combining regulatory, voluntary, and incentive-based protection programs; implementation of nearshore and shoreline habitat protection measures such as purchase and protection of estuary areas important for salmon productivity; protection and restoration of habitat functions in lower river areas, including deltas, side-channels, and floodplains important as rearing and migratory habitat; implementation of protective instream flow programs to reserve sufficient water for salmon production; and implementation of protective actions on agricultural lands.

Recent examples of habitat restoration and salmon recovery projects funded through the PCSRF and state sources that are expected to benefit listed Snohomish River steelhead population viability include:

- The Qwuloolt restoration project which restored 400 acres of diked, drained, and developed Snohomish River Delta. The project included extensive planning (1994-2006), property acquisition, property easements, structure demolition, garbage removal, stream channel relocation, ditch fill, berm building, native planting, storm water pond construction, setback levee construction, and levee breaching.
- Purchase and preservation of high quality floodplain, off-channel and riparian habitat between river mile four and five on the Tolt River, a tributary to the Snoqualmie River. One 6.33-acre parcel purchased borders 1,200 feet of a side channel to the Tolt River and the other 0.7-acre parcel purchased borders 160 feet of the Tolt River.
- Restoration of a 2.8-mile reach on the Lower Skykomish River to improve instream and floodplain habitat through placement of floodplain flood fencing interplanted with trees, modular log jam structures, habitat boulder-ballasted logs with rootwads, edge complexity wood structures, bio-engineered fabric, and plantings that will work with natural channel processes to promote habitat and water quality improvement, and to help safeguard the productivity of adjoining floodplain areas.
- Enhancement of degraded riparian and wetland areas adjacent to streams and shorelines in the Tulalip Bay area through riparian and wetland riparian planting projects, replacement of an undersized 4-foot diameter culvert, removal of approximately 4,900-sq ft. of non-native plant species from the stream bank and replacement with 4,900-sq ft. of native vegetation, supplementation of an additional 9,000 square feet of riparian area with native tree planting, placement of in-stream LWD, and channel realignment and habitat feature installation.
- Project design to remove a barrier to fish passage and improve the habitat in a back channel to the Snohomish River, resulting in re-connection of nearly 10 acres of back-channel habitat, 2.4 miles downstream of the confluence of the Skykomish and Snoqualmie rivers.
- Re-establishment of 50-foot-wide riparian buffers along 1 mile of the Pilchuck River through invasive vegetation control, planting native trees, exclusion of livestock, and installation of beaver fencing around trees to promote survival of native vegetation.
- The State of Washington allocated $3.7 million to renovate the Tokul Creek Hatchery water intake structure to meet the latest NMFS screening and fish passage criteria, and to restore a fish ladder in the dam to allow unimpeded fish passage in Tokul Creek, a Snoqualmie River tributary. Authorized for effects on listed fish by NMFS (NMFS 2016a), this work was completed in 2016, benefiting spatial structure and productivity of the listed Snoqualmie River watershed Chinook salmon and winter-run steelhead populations.

2.3.5 Integration of "All H" Environmental Baseline Factors

Consistent with their government-to-government salmon resource management standing with the U.S. federal government through the Treaty of Point Elliot, this opinion will take into account an "All H" approach developed by the Tulalip Tribes for implementing Puget Sound basin salmon recovery plans, including the plan for WRIA 7 and the habitat, harvest, and hatchery actions included therein (SSPS 2005). This recovery plan implementation approach - the "Snohomish Chinook Recovery Plan: Phases of Recovery and Integrated Adaptive Management Strategy" (Rawson and Crewson 2017) - harmonizes habitat actions, such as those described above, with hatchery and harvest salmon recovery actions and regulatory processes. Through the approach, a framework is applied within which "All H" actions and processes can be considered and evaluated jointly and concurrently. Emphasized in the approach is that recovery of ESA-listed Chinook salmon and steelhead will require significant management actions in all of the respective "Hs" - habitat, hydropower, harvest, and hatcheries - to recover listed fish species to a viable status.

The underlying scientific basis for this approach is that the design and execution of corrective actions is key to the conservation of species. Habitat, hydropower, harvest and hatchery management actions must be tailored to the conditions and limiting factors affecting the ESA-listed species in the watershed and then coordinated for maximum effectiveness. This is because the outcome of recovery efforts to improve the status of salmon natural populations depends on the combined and cumulative effect of "All H" actions. For example, the degree to which fish habitat is protected and restored to properly functioning conditions bears on the status of listed salmon and steelhead natural population abundance, productivity, diversity and spatial distribution. The condition of habitat, and progress in restoring it, determines the short and long-term status of the populations that may be affected by hatchery actions, and therefore the magnitude of hatchery-related effects on population and ESU viability, and the effectiveness of hatchery management actions to lessen risks.

The tribal approach for recovery plan implementation and consideration of "All H" actions is included in the Environmental Baseline section of this opinion as government-to-government guidance for considering effects of the proposed salmon hatchery actions on ESA- listed species. As such, in making determinations about the standing of proposed action effects on natural Chinook salmon and steelhead populations and ESU viability and the need for any responsive changes in the actions, NMFS will weigh the effects of implementation of concurrent habitat, harvest, and hatchery management actions to support recovery of ESA-listed fish in the Snohomish River basin.

Implementation of recovery-aimed habitat actions in isolation has failed to stem the total decline in habitat extent and condition in Puget Sound watersheds, including the Snohomish River basin (Treaty Indian Tribes of Western Washington 2011; Judge 2011). Based on available population status data (Section 2.2; Rawson and Crewson 2017 [Appendix 1]), ESA-listed Chinook salmon and steelhead in the action area remain at low population viability levels. The ESA-listed natural Chinook salmon populations in the watershed have not progressed beyond what is described in the tribal approach as the "preservation" stage (Snoqualmie Chinook salmon) or the initial phase of the "recolonization" stage

(Skykomish Chinook salmon), considering their current and recent past low viability status, and the poor to fair condition of habitat (Section 2.3.1; Rawson and Crewson 2017). The current degraded condition of habitat is adversely affecting productivity for the two Chinook salmon natural populations assigned to be within these recovery stages. Productivity for the two populations continues to decline, with naturally spawning fish productivity for both the Skykomish River and Snoqualmie Chinook salmon natural populations exhibiting recruit per spawner levels substantially below the replacement level for all but two brood years over the most recent eleven brood years (Rawson and Crewson 2017 - Appendix 1). Natural steelhead populations in the watershed are also exhibiting productivity levels well below replacement (Section 2.2.2.1), with all assignable to the "preservation" phase of restoration under the tribal approach, considering the fair to poor status of habitat.

Restored habitat cannot be successfully colonized by Chinook salmon and steelhead populations that are not replacing themselves. Acknowledged is that more than a century of habitat degradation that has adversely affected ESA-listed fish species survival and productivity in the Snohomish River basin will not be reversed in just a few years. Over the long term, NMFS expects that the benefits of "All H" recovery actions will be gradually and eventually realized, if habitat essential for ESA-listed Chinook salmon and steelhead viability is protected and restored as envisioned in the watershed recovery plan, and more favorable marine survival conditions return.

Based on the environmental baseline, actions that maintain recoverability of the ESA-listed species should be implemented and coordinated with remediation of the primary limiting factors. NMFS evaluation of hatchery program effects on ESA-listed Chinook salmon and steelhead natural populations will take into account the condition of habitat in conjunction with natural fish population status to determine which management actions will be most effective in addressing hatchery-related limiting factors and threats. For the Snohomish basin, hatchery program management actions implemented in isolation are not expected to measurably help the listed salmon and steelhead populations recover to the "local adaptation" and "full restoration" phases defined in Rawson and Crewson (2017). The "All H" recovery approach, largely focused on preserving and restoring fish habitat, is necessary to move the salmon and steelhead populations out of the initial phases of restoration.

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. The "effects of the action" means the direct and indirect effects of the action on the species and on designated critical habitat, together with the effects of other activities that are interrelated or interdependent, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the Proposed Action and are later in time, but still are reasonably certain to occur. Effects of the Proposed Action that are later in time (i.e., after expiration of the Proposed Action) are included in the analysis in this opinion. In Section 2.6, the Proposed Action, the status of ESA-protected species and designated critical habitat under the Environmental Baseline, and the cumulative effects of activities within the action area that are reasonably certain to occur are analyzed comprehensively to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA protected species.

2.4.1 Factors That Are Considered When Analyzing Hatchery Effects

For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany et al. 2000). NMFS defines population performance measures in terms of natural-origin fish and four key attributes: abundance, productivity, spatial structure, and diversity and then relates effects of the Proposed Action at the population scale to the MPG level and ultimately to the survival and recovery of an entire ESU or DPS.

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

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

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

As described in Section 2.1, NMFS's analyses of Proposed Action effects on ESA-listed Chinook salmon in the Snohomish River basin applies the PRA (NMFS 2010a), with other factors, to derive conclusions regarding Snohomish River basin salmon hatchery-related effects on the ESA-listed Puget Sound Chinook salmon ESU. The assigned standing of Skykomish Chinook salmon population as a Tier 2 population (secondary role in recovery of the ESU), and Snoqualmie Chinook as a Tier 3 population (tertiary role in recovery of the ESU) are factors in considering the magnitude of effects that would result from implementation of the Proposed Action at the population and ESU levels.

The effects, positive and negative, for two categories of hatchery programs on listed salmon and steelhead in the action area are summarized in Table 11. Generally speaking, effects range from beneficial to negative for programs that use local fish[6] for hatchery broodstock and from negligible to negative when a program does not use local fish for broodstock[7]. Only propagation programs that use fish that are integrated with the local natural population can benefit population viability. Integrated hatchery programs use local fish for broodstock (natural-origin and hatchery-origin fish included in an ESU or DPS), follow "best management practices", and are designed around natural evolutionary processes that promote population viability (NMFS 2004b). When hatchery programs produce fish that are not intended to spawn naturally, such as those that use fish originating from a different population, MPG, or from a different ESU or DPS, NMFS is particularly interested in how effective the program will be at isolating hatchery fish and avoiding co- occurrence and effects that potentially disadvantage fish from natural populations. The range in effects are refined and narrowed after available scientific information and the circumstances and conditions that are unique to individual hatchery programs are accounted for.

Table 11. Range in effects on natural population viability parameters from two categories of hatchery programs. The range in effects are refined and narrowed after the circumstances and conditions that are unique to individual hatchery programs are accounted for.

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

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

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
	Using natural fish for broodstock can reduce abundance.	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).

Information that NMFS needs to analyze the effects of a hatchery program on ESA-listed species must be included in an HGMP. Draft HGMPs are reviewed by NMFS for their sufficiency[8] before formal review and analysis of the Proposed Action can begin.

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

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

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, positive or negative, on population viability, and
(3) negative effect on population viability.

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

- the affected population(s) current risk level for abundance, productivity, spatial structure, and diversity (low, moderate, high, or very high);
- the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery;
- the target viability status (highly viable, viable, or maintained) for the affected natural population(s); and,
- the factors limiting population viability.

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

2.4.1.1 Broodstock collection

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

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

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

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

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). Effective population size, census size adjusted for variation in sex ratio and reproductive success, determines the level of genetic diversity that can be maintained by a population, and the rate at which diversity is lost. Effective size 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. Effective size is typically a per-generation measure. Diversity issues in anadromous salmonids are usually discussed in terms of the single-year version of N_e, the effective number of breeders (N_b).

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

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

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

Gene flow from other populations can have two effects. It can increase genetic diversity (e.g., Ayllon et al. 2006) which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression Figure 7. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstocks. Additionally, unusual rates of straying into other populations within or beyond the population's MPG or ESU or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (e.g., Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

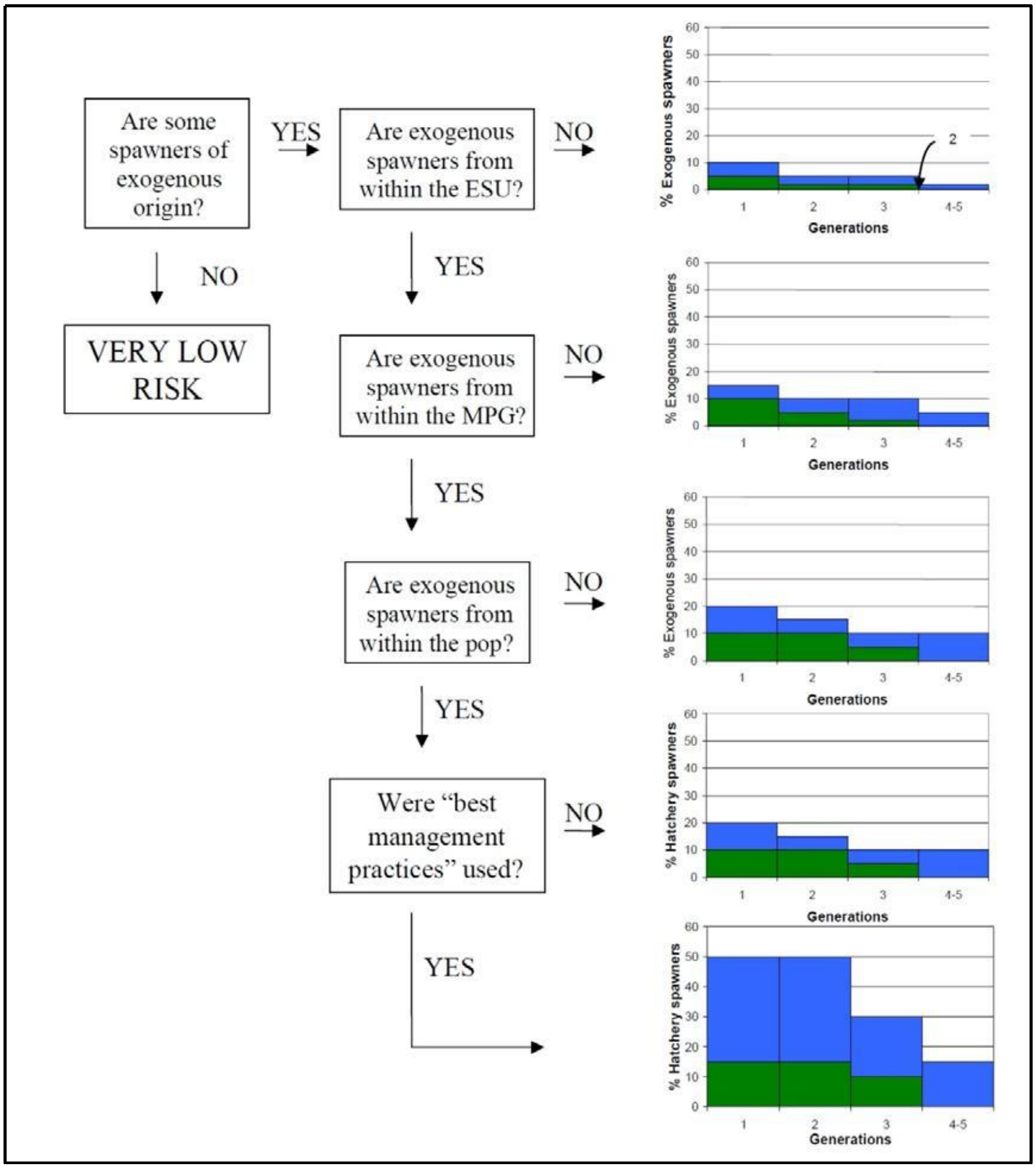

Figure 7. ICTRT (2007) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Green (darkest) areas indicate low risk combinations of duration and proportion of spawners, blue (intermediate areas indicate moderate risk areas and white areas and areas outside the graphed range indicate high risk. Exogenous fish are considered to be all fish hatchery origin, and non-normative strays of natural origin.

The proportion of hatchery fish among natural spawners, or "pHOS", is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze hatchery affects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before finally spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be applied in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Blankenship et al. 2007; Saisa et al. 2003). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Leider et al. 1990; McLean et al. 2004; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

Hatchery-influenced selection (often called domestication) occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. Hatchery-influenced selection can range from relaxation of selection, that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1991).

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. Theoretically, 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 for 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, and in some studies (e.g., Anderson et al. 2012), 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 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[9]. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS: see Figure 7).

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), and divided hatchery programs into two categories called integrated and segregated (isolated). Functionally the distinction is based on linking the broodstock to the natural population: integrated programs use some level of natural-origin fish as broodstock and segregated do not. Guidelines for isolated programs as recommended by the HSRG are based on pHOS, but recommended HSRG guidelines for integrated programs are also based on a metric called proportionate natural influence (PNI), which is a function of pHOS and the proportion of natural-origin fish in the broodstock (pNOB)[10]. PNI is in theory a reflection of the relative strength of selection in the hatchery and natural environments: a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. For a population of high conservation importance their guidelines are a pHOS of no greater than 5% for segregated programs or a pHOS no greater than 30% and PNI of at least 67% for integrated programs (HSRG 2009). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk, in the short-term. HSRG (2004) offered additional guidance regarding segregated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. The HSRG recently produced an update report (HSRG 2014) in which they stated that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly segregated programs in which no hatchery-origin returnees interact

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[9] 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.

[10] 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.

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

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 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 was clarified in the 2014 update document (HSRG 2014), which stated that the metric of interest is effective pHOS.

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

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

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

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

where $pHOS_{census}$ is the proportion of the naturally spawning population that is composed of hatchery-origin adults (HSRG 2014).[11]

[11] During our analysis we determined that this equation was erroneous, and that the correct equation was: pHOSeff =rrs*pHOS/(rrs*pHOS+(1-pHOS). We discuss this in section 2.4.2.2.

Adjusting census pHOS by RRS should be done very cautiously as the Ford (2002) model, the foundation of the HSRG gene flow guidelines, implicitly includes a genetic component of RRS. In that model, hatchery fish are expected to have RRS < 1 (compared to natural fish) due to selection effects in the hatchery that are assumed to be genetically heritable and detrimental. A component of reduced RRS of hatchery fish is therefore already incorporated in the model and by extension the calculation of PNI and reducing pHOS values by multiplying by RRS will result in underestimating the relevant pHOS and therefore overestimating PNI. Such adjustments would be particularly inappropriate for hatchery programs with low pNOB, as these programs may well have a substantial reduction in RRS due to genetic factors already incorporated in the model.

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

PNI is an approximation of relative trait value, based on a simplistic model that may fail to capture important biological information, so including this information in the underlying models may be more accurate than making ad hoc adjustments to a statistic intended to be rough guideline for managers. We look forward to research clarifying this issue in the near future. In the meantime, except for cases in which gene flow data reflecting natural spawning effects of hatchery-origin fish are available, or an adjustment for RRS has strong justification, NMFS feels that census pHOS is the appropriate metric to use for genetic risk evaluation.

Additional perspective on pHOS that is independent of HSRG modelling is provided by a simple analysis of the expected proportions of mating types. Figure 8 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly[12]. For example, the vertical line on the diagram marks the situation at a census pHOS level of 10%. At this level, expectations are that 81% of the matings will be NxN, 18% will be NxH, and 1% will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10% will have an 81% chance of having two natural-origin parents, etc.

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

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

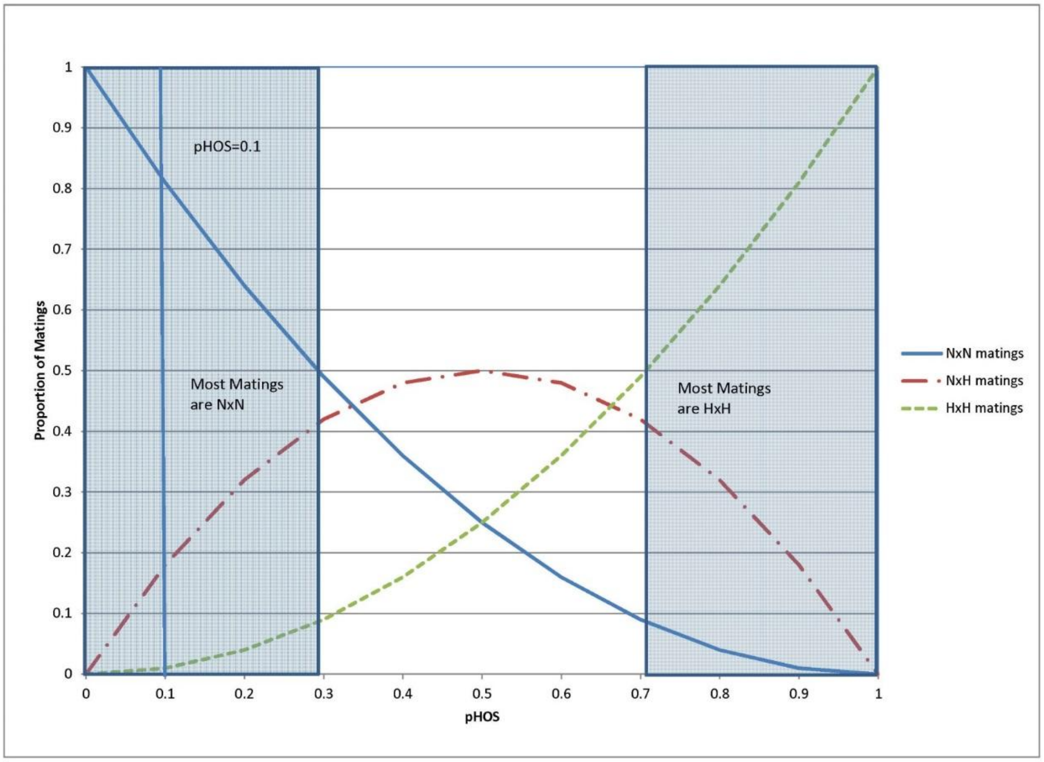

Figure 8. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS) (NxN – natural-origin x natural-origin; NxH – natural-origin x hatchery; HXH – hatchery x hatchery).

Ecological effects included under this factor (i.e., "[h]atchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds") refer to effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects of hatchery fish on the spawning grounds may be positive or negative. In that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Kline et al. 1990; Piorkowski 1995; Larkin and Slaney 1996; Wipfli et al. 1998; Gresh et al. 2000; Murota 2002; and Quamme and Slaney 2002). As a result, the growth and survival of juvenile salmonids may increase (Hager and Noble 1976; Bilton et al. 1982; Holtby 1988; Ward and Slaney 1988; Hartman and Scrivener 1990; Johnston et al. 1990; Quinn and Peterson 1996; Bradford et al. 2000; Bell 2001; Brakensiek 2002).

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

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

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

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

Competition may result from direct interactions, or through indirect means, as when utilization of a limited resource by hatchery fish reduces the amount available for naturally produced fish (SIWG 1984). Specific hazards associated with competitive impacts of hatchery salmonids on listed naturally produced salmonids may include competition for food and rearing sites (NMFS 2012). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (SIWG 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at "high risk" due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

Several factors influencing the risk of competition posed by hatchery releases: whether competition is intra- or interspecific; the duration of freshwater co-occurrence of hatchery and natural-origin fish; relative body sizes of the two groups; prior residence of shared habitat; environmentally induced developmental differences; and, density in shared habitat (Tatara and Berejikian 2012). Intraspecific competition would be expected to be greater than interspecific, and competition would be expected to increase with prolonged freshwater co-occurrence. 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 naturally produced rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and naturally produced juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

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

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

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990; California HSRG 2012).
- Releasing all hatchery fish at times when natural-origin fish vulnerable to resource competition are not present in downstream areas in substantial numbers.
- Releasing all hatchery fish after the majority of sympatric natural-origin juveniles have emigrated seaward to reduce the risk of competition for food and space.
- Operating hatcheries such that hatchery fish are reared to sufficient size and uniform individual size such that smoltification occurs in nearly the entire population (Bugert *et al.* 1992).
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing naturally produced juveniles.

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

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

Another important possible ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (direct consumption) or indirect (increases in predation by other predator species due to enhanced attraction) can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish and by the progeny of naturally spawning hatchery fish (direct predation effects), and predation by avian and other predators attracted to the area by an abundance of hatchery fish (indirect effects). 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 as smolts that emigrate quickly to the ocean can prey on fry and fingerlings that are encountered during the downstream migration. As mentioned above, some of these hatchery fish do not emigrate and instead take up residence in the stream (residuals) where they can prey on stream-rearing juveniles over a more prolonged period. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance and when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

SIWG (1984) rated most risks associated with predation as unknown, because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead, and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1985; Hawkins and Tipping 1999; Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead timing and release protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat, predominately) than their hatchery counterparts.

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

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

Some reports suggest that hatchery fish can prey on fish that are up to 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 (Columbia Basin Fish and Wildlife Authority) 1996; Hillman and Mullan 1989; Horner 1978). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Bachman 1984; Olla et al. 1998; Sosiak et al. 1979).

Large concentrations of migrating hatchery fish may attract predators (birds, fish, and seals) and consequently contribute indirectly to predation of emigrating wild fish (Steward and Bjornn 1990). The presence of large numbers of hatchery fish may also alter natural-origin salmonid behavioral patterns, potentially influencing their vulnerability and susceptibility to predation (Hillman and Mullan 1989; USFWS 1994; Kostow 2008). Hatchery fish released into natural-origin fish production areas, or into migration areas during natural-origin fish emigration periods, may therefore pose an elevated, indirect predation risk to commingled listed fish. Alternatively, a mass of hatchery fish migrating through an area may overwhelm established predator populations, providing a beneficial, protective effect to co-occurring natural-origin fish. Newly released hatchery-origin smolts generally exhibit reduced predator avoidance behavior relative to co-occurring natural-origin fish (Bori and Davis 1989; and as reviewed in Flagg et al. 2000). Also, newly released smolts have been found to survive at a reduced rate during downstream migration relative to their natural-origin counterparts (Flagg et al. 2000; Melnychuk et al. 2014). These studies suggest that predator selection for hatchery-origin and natural-origin fish in commingled aggregations is not equal. Rather, the relatively naïve hatchery-origin fish may be preferentially selected in any mixed schools of migrating fish until they acclimate to the natural environment, and hatchery fish may in fact sate (and swamp) potential predators of natural-origin fish, shielding them from avian, mammal, and fish predation.

There are several management actions 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.
- Releasing all hatchery fish at times when natural-origin fish of individual sizes vulnerable to direct predation are not present in downstream areas in substantial numbers.
- Releasing all hatchery fish after the majority of sympatric natural-origin juveniles have emigrated seaward to reduce the risk that avian, mammal, and fish predators may be attracted to commingled abundances of hatchery and natural-origin salmon or steelhead.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of

interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.

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

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

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

2.4.1.5 Research, monitoring, and evaluation

NMFS also analyzes proposed RM&E actions for effects on listed species and on designated critical habitat. Generally speaking, negative effects to 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 effects of the proposed RM&E on the species and on designated critical habitat, (2) critical uncertainties over effects of the Proposed Action on the species, (3) performance monitoring and determining the effectiveness of the hatchery program at achieving its goals and objectives, (4) identifying and quantifying collateral effects, and (5) tracking compliance of the hatchery program with the terms and conditions for implementing the program. After assessing the proposed hatchery RM&E and before it makes any recommendations to the action agencies, NMFS considers the benefit or usefulness of new or additional information, whether the desired information is available from another source, the effects on ESA-listed species, and cost.

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

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

2.4.1.6 The operation, maintenance, and construction of hatchery facilities

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

2.4.1.7 Fisheries

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

2.4.2 Effects of the Proposed Action

Analysis of the proposed actions identified three risk factors that may potentially have negative effects on ESA protected Puget Sound Chinook salmon and/or Puget Sound steelhead and on designated critical habitat, and one factor that is likely to be beneficial to listed Puget Sound Chinook salmon. The Proposed Actions would have a negligible effect on six other hatchery-related risk factors, and effects are not applicable for the remaining factors. A summarized analysis of all applicable (i.e., negative, beneficial, or negligible) hatchery effect factors is presented below (Table 12), followed by an expanded discussion of effects assigned for each applicable factor. The framework NMFS followed for analyzing effects of the proposed hatchery programs is described in Section 2.4.1 of this opinion.

Table 12. Summarized effects of the Snohomish River basin hatchery salmon programs on Puget Sound Chinook salmon and Puget Sound steelhead and their designated critical habitat.

Factors	Range in Potential Effects for This Factor	Analysis of Effects for Each Factor
Broodstock collection when broodstock originate from the same ESU or DPS	Beneficial to negative effect	**Puget Sound Chinook salmon: Negative effect** Broodstock are adult natural- and hatchery-origin fish returning to the Snohomish River basin. Both components of the return represent the extant native Skykomish summer Chinook stock and are part of the listed ESU (Jones 2011). The hatchery programs operate for harvest augmentation purposes using the native Skykomish stock as a donor. All broodstock are collected from the Skykomish River summer Chinook from returns to the Wallace River, the South Fork Skykomish River (Sunset Falls Fishway), or Tulalip Hatchery. Collection of natural-origin fish at Sunset Falls and from the Wallace River reduces the number of natural-origin fish spawning naturally, which may potentially have negative genetic diversity and productivity consequences for the Skykomish population. No broodstock collection occurs in the Snoqualmie River, or at the time of the season, where and when the Snoqualmie fall Chinook stock would be affected. Best management practices are applied to help ensure broodstock collection, selection, mating, rearing, and release practices do not lead to adverse demographic (e.g., mining), genetic and ecological effects on either of the listed Chinook salmon populations in the Snohomish watershed. Chinook salmon are passed upstream above the Wallace River weir to seed natural habitat with naturally spawning fish, and migration and blockage effects are minimized at the weir through timely handling of trapped fish. Broodstock collection activities targeting coho and fall chum salmon under the proposed actions would occur at times and locations substantially removed from natural-origin Chinook salmon migration and spawning times and areas. **Puget Sound Steelhead: Negligible effect** The species is not collected as broodstock or propagated as part of the proposed actions. Salmon broodstock collection activities under the proposed actions occur well in advance seasonally of the adult steelhead migration and spawning periods and/or in areas removed from steelhead migration and spawning areas. Incidental captures and effects on steelhead from those activities are therefore unlikely.
Broodstock collection when broodstock originate from a different ESU or DPS	Negligible to negative effect	**Puget Sound Chinook salmon: Not applicable** There are no broodstock collected in the proposed WDFW and Tulalip Chinook Hatchery programs originating from a different ESU. The native Skykomish Chinook salmon hatchery and natural aggregations are used as broodstock. **Puget Sound Steelhead: Not applicable** The species is not propagated as part of the proposed actions, and no steelhead originating from another DPS will be collected as broodstock.

Factors	Range in Potential Effects for This Factor	Analysis of Effects for Each Factor
Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds that are included in the same ESU or DPS	Beneficial to negative effect	**Puget Sound Chinook salmon:** **Genetic Diversity: Negative effect;** **Spawning Ground Competition/Redd Superimposition: Negligible effect;** **Population Viability: Negligible to beneficial effect (Skykomish), - Negligible effect (Snoqualmie);** **Marine-derived Nutrients: Negligible effect.** First or subsequent generation Chinook salmon adults produced through the WDFW and Tulalip hatchery programs have the potential to adversely affect the genetic diversity and fitness of the Skykomish and Snoqualmie populations when hatchery-origin fish stray into natural spawning areas and spawn naturally. Measures would be applied to avoid genetic divergence between the propagated and naturally spawning Skykomish aggregations, limit unintentional straying, and thus, keep genetic risks low. Extensive monitoring and evaluation actions would be implemented to determine hatchery-origin fish escapement levels and proportions, and genetic introgression effects on the two natural-origin Chinook salmon populations in the Snohomish River basin. The very latest returning hatchery-origin coho salmon adults from the Wallace River Hatchery program may spawn in the same areas where Skykomish or Snoqualmie natural-origin Chinook salmon spawn, potentially leading to adverse spawning ground competition and redd superimposition effects. However, the majority of coho salmon spawn later in the season, and in different river reaches, so there is very little spatial or temporal overlap between naturally spawning Chinook salmon and naturally spawning coho. Although produced for fisheries harvest augmentation purposes, Skykomish stock Chinook salmon produced through the WDFW and Tulalip hatchery programs are part of the listed Skykomish population. Because of the origin of the hatchery stock, and measures applied in the hatcheries to minimize genetic divergence from the natural population, the programs may benefit the abundance and spatial structure of the Skykomish Chinook population through unintentional augmentation of natural spawning abundances. The programs may also serve as genetic reserves for the Skykomish population. The proposed coho and fall chum salmon programs would have negligible effects on listed Chinook salmon population viability. The salmon hatchery programs would have negligible effects on the viability or productivity of the Snoqualmie Chinook population. The carcasses of naturally spawning hatchery-origin salmon and spawned broodstock originating from the hatchery programs would benefit listed Chinook salmon population productivity in the watershed by increasing the amount of

Factors	Range in Potential Effects for This Factor	Analysis of Effects for Each Factor
		marine derived nutrients. However, the level of benefit would be negligible relative to contributions afforded by naturally spawning natural-origin salmon. **Puget Sound Steelhead:** **Marine-derived Nutrients: Negligible effect;** **Other factors: Not Applicable** The carcasses of stray, naturally spawning salmon and spawned broodstock originating from the hatchery salmon programs would benefit listed steelhead population productivity in the watershed by increasing the amount of marine derived nutrients. However, the level of benefit would be negligible relative to contributions afforded by naturally spawning natural-origin salmon. There would be no genetic diversity or other effects on naturally spawning adult steelhead in the Snohomish River basin. The species is not propagated as part of the proposed actions, and there would therefore be no adult hatchery steelhead produced that would stray into natural spawning areas. The earlier spawn timing for Chinook, coho and fall chum salmon relative to steelhead makes adult fish interactions and substantial competitive or redd superimposition effects in listed steelhead spawning areas unlikely.
Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds that are not included in the same ESU or DPS	Negligible to negative effect	**Puget Sound Chinook salmon: Not applicable** There are no Chinook salmon propagated in the proposed WDFW and Tulalip Chinook salmon hatchery programs originating from a different ESU that would escape to spawn in natural production areas. **Puget Sound Steelhead: Not applicable** The species is not propagated as part of the proposed actions, and there would therefore be no adult hatchery steelhead produced of any origin that would stray into natural-origin steelhead spawning areas.
Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas	Negligible to negative effect	**Puget Sound Chinook salmon:** **– Negative effect (Wallace River Hatchery yearling Chinook and coho salmon; Eagle Creek Hatchery coho salmon)** **Puget Sound steelhead:** **- Negligible effect (Wallace River Hatchery yearling Chinook and coho salmon; Eagle Creek Hatchery coho salmon)** **Puget Sound Chinook salmon and Puget Sound steelhead:** **- Negligible effect (Wallace River Hatchery subyearling Chinook salmon and all Tulalip hatchery salmon releases)** Interactions of general concern in juvenile rearing areas are fish disease pathogen transfer and amplification; competition between hatchery-origin salmon and natural-origin Chinook salmon and steelhead for food and space; and hatchery fish predation on natural-origin fish. Implementation of co-

Factors	Range in Potential Effects for This Factor	Analysis of Effects for Each Factor
		manager fish health protocols would substantially minimize the risk of fish disease pathogen transfer and amplification associated with salmon production through the programs. The upper watershed release location at Wallace River (tributary to the Skykomish River at RM 35.7), large individual size, and spring release timing of yearling Chinook salmon and coho salmon produced by Wallace River Hatchery may lead to predation on co-occurring juvenile natural-origin Chinook salmon. Eagle Creek Hatchery coho salmon may prey on juvenile Chinook salmon for the same reasons. Adverse resource competition effects on natural-origin listed fish associated with Wallace River Hatchery and Eagle Creek Hatchery yearling releases are unlikely because of substantial size and hence prey differences between the hatchery yearlings and natural-origin salmonids, and the demonstrated tendency for hatchery yearling smolts to emigrate rapidly from the watershed and disperse into marine areas. Because of their small size, and late release timing that minimizes spatial and temporal overlap with natural-origin salmon and steelhead, subyearling Chinook salmon released from Wallace River Hatchery are unlikely to have substantial adverse ecological effects on listed juvenile natural-origin fish. Tulalip Hatchery subyearling Chinook, yearling coho, and fall chum fry releases into the Tulalip Bay watershed and Tulalip Bay are unlikely to adversely affect natural-origin juvenile Chinook salmon and steelhead because temporal and spatial overlap between the groups would not be substantial. All hatchery-origin salmon would be released in healthy condition as seawater-ready, migrating smolts or fry to ensure rapid emigration downstream through watershed areas where interactions with rearing listed fish may occur. Fish size, behavior, population individual size uniformity (goal CV of <10%), and morphology would be monitored at the hatchery rearing locations to assess readiness of the fish for release as smolts. BMPs ("best management practices") included in the HGMPs and proposed for juvenile salmon rearing and release would reduce the risk of adverse ecological interaction effects (competition and predation) on listed natural-origin fish populations in the Snohomish River basin, while promoting high juvenile fish to adult return survival rates consistent with meeting proposed program harvest augmentation objectives. *Fish Disease Pathogen Transfer and Amplification* - The six proposed HGMPs address general threats from fish disease pathogen transfer and amplification. The plans describe fish disease pathogen issues of concern and actions that would be implemented to minimize risks of disease transfer and amplification. All hatchery actions would be implemented in accordance with the "The Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State" (NWIFC and WDFW 2006). Protocols described in the policy and

Factors	Range in Potential Effects for This Factor	Analysis of Effects for Each Factor
		applied through the programs would help reduce risks of fish disease to propagated and natural fish populations through regular fish health monitoring and reporting, and application of BMPs to reduce fish health risks. *Competition* – For all Tulalip tribal hatchery salmon releases, there is negligible risk of spatial and temporal overlap between juvenile hatchery-origin and listed natural-origin fish that might lead to substantial competition effects in freshwater. There are no listed fish populations in the Tulalip Bay watersheds where the salmon are released. The seawater-ready smolt/fry-only release practices applied at the tribes' hatchery facilities would lead to rapid dispersal of hatchery-origin salmon into pelagic marine waters (Rowse and Fresh 2003; Beamer et al. 2006), removed from nearshore seawater transition areas where Snohomish River basin natural-origin juvenile salmonids may be concentrated. Further, Tulalip Hatchery-origin subyearling Chinook salmon are released between May 5 and May 25, after the majority of natural-origin Chinook salmon from the Snohomish River basin have emigrated seaward. For Wallace River Hatchery subyearling Chinook salmon, the release of fish in June would minimize the likelihood for interactions with natural-origin Chinook salmon, which emigrate seaward earlier in the year. Subyearling Chinook salmon releases are also unlikely to affect juvenile steelhead, which rear predominately in upper watershed reaches in the basin, and that emigrate as smolts in lower watershed areas in April and May. Yearling Chinook and coho salmon released in spring from Wallace River Hatchery, and coho salmon released through the Eagle Creek Hatchery program, are much larger in size than co-occurring juvenile natural Chinook salmon that would be encountered, and the two groups would likely have different diet preferences. In addition, yearling fish produced by the program would be released as uniform-sized seawater-ready smolts as a measure to foster rapid emigration seaward, and clearance from watershed areas where they may interact with natural-origin Chinook salmon and steelhead. The co-managers have included hatchery management measures in the proposed HGMPs designed to reduce competition risks to listed juvenile fish from hatchery-origin salmon in the action area. *Predation* – For all Tulalip Tribal hatchery salmon releases, there is negligible risk of spatial and temporal overlap between juvenile hatchery-origin and ESA-listed natural-origin fish that might lead to substantial predation effects in freshwater. There are no listed fish populations in the Tulalip Bay watershed where the salmon are released. The seawater-ready smolt/fry-only release practices applied at the tribal hatchery facilities would lead to rapid dispersal of hatchery-

Factors	Range in Potential Effects for This Factor	Analysis of Effects for Each Factor
		origin salmon into pelagic marine waters (Rowse and Fresh 2003; Beamer et al., 2006), removed from nearshore seawater transition areas where Snohomish River basin natural-origin juvenile salmonids may be concentrated, and where predation by Tulalip Hatchery-origin yearling coho salmon would be of concern. Further, Tulalip Hatchery-origin subyearling Chinook salmon are released in early- to late-May, after the majority of natural-origin Chinook salmon from the Snohomish River basin have emigrated seaward. Tulalip Hatchery-origin fall chum fry predation on listed fish species is not a concern, because the chum are too small in individual size to prey on listed fish, and the non-piscivorous feeding nature of juvenile chum salmon. Subyearling Chinook salmon produced through the Wallace River Hatchery program are liberated in June, after the majority of juvenile natural-origin Chinook salmon have emigrated seaward, limiting the likelihood for substantial interactions. Further, the small individual size of the hatchery subyearling would make predation on any co-occurring natural-origin salmon and steelhead an unlikely event. The hatchery-origin species and life stages with substantial spatial and temporal overlap with juvenile listed Chinook salmon of an average individual size vulnerable to predation would be yearling Chinook and coho salmon released from Wallace River Hatchery, and coho salmon released through the Eagle Creek Hatchery program. The yearlings are released relatively high in the Skykomish River watershed and/or in months when emigrating Chinook salmon fry and parr are present. The yearling fish would not encounter juvenile steelhead of a size vulnerable to predation, as young-of-the-year steelhead fry emerge later in the season and higher in the watershed, months after the yearlings would be released. Only larger, yearling and two-year old steelhead would be present in freshwater areas downstream of the hatchery release site. The proposed programs for yearling Chinook and coho salmon would reduce the potential for predation on natural-origin juvenile Chinook salmon by releasing only uniform-sized smolts that emigrate seaward and disperse into pelagic waters rapidly, minimizing the duration of interaction with listed fish in freshwater and lower river estuarine areas, and reducing opportunities for predation.
Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean	Negligible to negative effect	**Puget Sound Chinook salmon and Puget Sound steelhead - Negligible effect** Effects for this category of the Proposed Action are not detectable. Available information does not show the level of hatchery production that leads to measurable ecological effects in the Salish Sea and the Pacific Ocean, including fish disease pathogen disease transfer, competition, and predation, nor does it identify how and to what extent listed species would be disadvantaged. The conditions under which any

Factors	Range in Potential Effects for This Factor	Analysis of Effects for Each Factor
		ecological interactions occur are unknown, and advantages and disadvantages for different fish origins, life-history stages, populations, ESUs, and DPSs are not detectable.
Hatchery research, monitoring, and evaluation	Beneficial to negative effect	**Puget Sound Chinook salmon and Puget Sound steelhead - Negligible effect** The primary monitoring and evaluation objectives for the hatchery plans are to: assess the effects of artificial propagation on natural-origin salmonids, including listed Snohomish River basin Chinook salmon and steelhead populations; and to determine the performance of the programs in producing adult salmon for harvest as mitigation for lost natural-origin salmon production in the Snohomish River basin. Monitoring and evaluation actions that would be implemented to determine whether these objectives are met include spawning ground/redd surveys and hatchery escapement monitoring to determine total Chinook, coho and fall chum salmon spawning abundances to the basin and the hatcheries. The number and distribution of tagged, untagged, and otolith marked fish harvested in fisheries and escaping to the basin each year would be monitored to determine the status of the natural- and hatchery-origin salmon total return and escapement abundances and proportions relative to goal levels. In addition to regular foot surveys to census salmon spawning abundance, redds will be enumerated and carcasses will be sampled to identify fish origin in natural spawning areas, adult fish abundance, origin, and distribution data would be collected through monitoring of weir counts in the Wallace River and Battle Creek, and as authorized through a separate ESA consultation, at the Sunset Falls Fishway. Adult fish return abundance, timing, age class, sex ratio, mark/tag status, disposition, holding mortality, and fish health condition data would be collected at all hatchery facilities to monitor the effects of the programs in increasing adult returns and maintaining the run traits of the associated natural-origin populations. Juvenile fish outmigrant data collected by the Tulalip Tribes through annual operation of downstream-migrant traps in the mainstem Skykomish and Snoqualmie rivers (as per NMFS 2017a) would allow for assessment of the natural spawning success of the salmon populations from actions evaluated through this consultation. The effects of these RM&E actions on listed Chinook salmon and steelhead are expected to be negligible.
Operation, maintenance, and construction of hatchery facilities	Beneficial to negative effect	**Puget Sound Chinook salmon and Puget Sound steelhead - Negative to negligible effect** Wallace River Hatchery water intake and discharge screens do not use the latest technology to protect juvenile fish from entrainment and injury. Although the hatchery water intake screens on the Wallace River and in May Creek are in compliance with state and federal guidelines (NMFS 1995, 1996), they do not meet the newest NMFS Anadromous Salmonid Passage Facility Design Criteria (NMFS 2011c). WDFW has indicated the intent to modify screening at

Factors	Range in Potential Effects for This Factor	Analysis of Effects for Each Factor
		Wallace River Hatchery to comply with the latest NMFS screening criteria (WDFW 2013a). Intake screens on both tributaries affected by Wallace River Hatchery are scheduled by WDFW for rebuild by fall 2020 to bring the screens into compliance with current NMFS criteria. Screening at the Tulalip Tribes' hatchery facilities, and at Eagle Creek Hatchery, is not a risk factor as there are no listed fish populations present in the small tributaries where the facilities are located. Operation of the hatchery programs is unlikely to degrade water quality. Water used for hatchery operations at the Wallace River Hatchery and Tulalip Hatchery facilities is monitored, treated, and discharged in accordance with current NPDES permits that limit effects on downstream aquatic life. Monthly and annual fish production at the Everett Bay Net-Pen facility is below levels of concern regarding water quality impacts and the need for effluent discharge limits. There are no construction activities proposed for the hatchery actions, and no routine hatchery maintenance activities are expected to adversely modify designated critical habitat for listed species.
Fisheries	Beneficial to negative effect	**Puget Sound Chinook salmon and Puget Sound steelhead – Not Applicable** Fisheries are not included as part of the proposed actions. Marine fisheries catch salmon produced in the Snohomish River basin only incidentally, and are therefore not interrelated or interdependent with this action. Salmon fisheries within the basin action area are dependent on the continued production of hatchery Chinook, coho, and fall chum salmon, and are therefore interrelated and interdependent with this action. NMFS's authorization for 'take' of ESA-listed fish in Puget Sound marine fisheries and in associated freshwater fishing areas, including in the Snohomish River basin action area, is addressed annually or on a multi-year basis through a separate ESA section 7 consultation (most recently NMFS 2017) on the current Puget Sound harvest plans assembled by the co-managers. Past effects of fisheries in the three basins are discussed in the Environmental Baseline section. Similar fisheries and the same or lesser effects are expected going forward.

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

Negative effect: Chinook salmon collected for use as hatchery broodstock are adult natural- and hatchery-origin fish returning to the Snohomish River basin. Both components of the return represent the extant native Skykomish Chinook population and are part of the ESA-listed Puget Sound Chinook salmon ESU (Jones 2011). Under the proposed actions, broodstock would be collected from Skykomish River summer Chinook salmon returning to the Wallace River, the South Fork Skykomish River (Sunset Falls Fishway), and/or Tulalip Hatchery. Natural-origin adults collected in the Wallace River and at

Sunset Falls Fishway are incorporated as broodstock at Wallace River Hatchery. This practice adversely impacts natural-origin abundance, but positively impacts genetic effects by ensuring that the hatchery fish released from Wallace River Hatchery remain genetically similar to the naturally produced Skykomish Chinook salmon population, reducing the risk of hatchery-influenced selection.

To address the risk of adverse effects to the Skykomish Chinook salmon population, best management practices are applied to help ensure broodstock collection, selection, mating, rearing, and release actions do not lead to adverse demographic (e.g., mining), genetic, and ecological effects on either of the listed Chinook salmon populations in the Snohomish River basin. These practices include limiting the number of natural-origin Chinook salmon adults held for spawning at the Wallace River Hatchery to no more than 400 fish. NMFS has conferred with the applicants to discuss how this will be exercised in years with low numbers of returning adults.

The collection goal is based on a sliding scale (Table 13), to allow moderation of the number of NORs incorporated as broodstock considering the best available estimate of annual abundance relative to the low abundance threshold (LAT)[14] of 1,745 natural origin fish for the Skykomish Chinook salmon population. Note that collection of NORs can also be moderated based on environmental conditions, in particular, critically high water temperatures (Section 2.3.1) at the collection and holding facilities. In 2017, Wallace River Hatchery experienced near total mortality of NORs collected at the hatchery trap, when elevated water temperatures exacerbated fish losses due to fish disease pathogens (Mike Crewson, Tulalip Tribes, pers. comm., September 18, 2017).

If the program is not able to meet the pNOB goal as well as the pHOS goal discussed below, this would trigger review where all of the relative causative factors affecting the surrogate take metric(s) would be evaluated together. NMFS would weigh the effects of all concurrent harvest and hatchery management actions with all relevant habitat and climate change effects that bear on the surrogate metric(s) before recommending any corrective actions pertaining to the Proposed Action.

All Chinook salmon trapped in excess of broodstock needs will be released into natural spawning and migration areas. Additional measures are in place to protect the natural-origin run. These measures include a limit on the annual number or proportion of the total natural-origin adult return to Sunset Falls, and management of broodstock removals at the fishway such that total natural-origin Chinook salmon escapement in the Skykomish watershed does not fall below the established LAT of 1,745 spawners. No natural-origin Chinook will be removed from Sunset Falls if the natural Skykomish Chinook escapement is forecasted to be in critical status. In years where the forecast adult natural-origin return is above critical status, removals will be halted if in-season data indicate the actual run-size is returning at or below the critical level. The proposed maximum Sunset Falls Fishway natural-origin fish broodstock collection level and contingency protocols are designed to limit the threats to spatial distribution and abundance, and hence genetic diversity reduction effects of removing natural-origin fish from the naturally spawning Skykomish population.

[14] The decision of whether NOS abundances are above or below the LATs must be made by the co-managers utilizing the best available pre-season or in-season assessments of NOR abundances available at the time of broodstock collections completed July-September annually. However, the intent in any given year is to use all of the NORs encountered at the Wallace River Hatchery rack, up to the 400 fish ceiling, subject to environmental conditions and available escapement.

Table 13. Sliding Scale for integration of natural origin recruits (NOR) collected at Sunset Falls or at Wallace River Hatchery into the Wallace River Hatchery broodstock, based on low abundance threshold (LAT) predictions. When the NOR return is forecast to be >100% of the LAT, no more than 225 fish will be collected at Sunset Falls, and only volunteers to the Wallace River Hatchery rack will be collected when the run prediction is below the LAT. Collection of fish at the Wallace River Hatchery rack may be adjusted downward based on the best available pre- or in-season estimate of natural-origin Skykomish Chinook salmon abundance relative to the LAT. Further downward adjustments in NOR collections at Wallace River Hatchery can occur in accordance with the best judgement of the operators, when environmental conditions (e.g., high water temperatures) are detrimental to salmon survival.

Forecasted escapement in relation to Skykomish Chinook LAT	Target number of NORs to be incorporated into broodstock
> 100%	300-400
75-99%	225- 299
50-75%	150-224
25-50%	75-149
≤ 25%	0-74

Broodstock are collected from the run at large at all trapping/capture sites. Chinook salmon are passed upstream above the Wallace River weir to seed natural habitat with naturally spawning fish, and migration and blockage effects are minimized at the weir through timely handling of trapped fish. No broodstock collection occurs in the Snoqualmie River, or at the time of the season, where and when the Snoqualmie Chinook stock would be affected.

All juvenile fish released through the programs would be marked, tagged, and/or fin clipped to allow for their differentiation from natural-origin salmon after their release from the hatcheries and when the fish return as adults to Snohomish River basin marine and freshwater areas. Mass adipose fin-marking and/or coded wire tagging of Chinook salmon would enable detection and parsing of returning adult fish by origin during broodstock collection operations that would help meet genetic diversity preservation objectives. All Chinook salmon originating from both the Wallace River and Tulalip hatchery programs will be identifiable through application of either an adipose fin clip only, adipose fin clip/CWT combination, or CWT only as part of a DIT group. All Chinook salmon produced by both Wallace River and Tulalip hatchery programs would be differentially thermally otolith marked by hatchery of origin and brood year.

Measures are applied that would adequately safeguard the health and abundance of ESA-listed salmon and steelhead that may be affected directly or incidentally by broodstock collection activities associated with the proposed Wallace River Hatchery coho salmon hatchery program. Coho salmon broodstock would be collected as volunteers to the Wallace River Hatchery and Sunset Falls Fishway traps during the adult return period for the species, and incidental effects on listed Chinook salmon and steelhead are unlikely, because these listed fish species have different adult migration timings and would not recruit to the coho salmon trapping locations in substantial numbers. In-river activities proposed to collect Chinook salmon as broodstock would be limited in years when adults were not volunteering to the traps at required broodstock collection levels. Chinook salmon would be collected for broodstock in the Wallace River by seining, restricted to the area immediately below the Wallace River Hatchery weirs.

Non-target, listed fish are avoided in watershed areas outside of the hatcheries where Chinook salmon broodstock are collected.
Steelhead would not be collected as adults for use in hatchery propagation as part of the proposed hatchery actions. Because winter-run steelhead have a later return timing as adults (December to May), substantial numbers of listed Snohomish River basin winter-run steelhead are unlikely to be encountered or affected during the June through December periods when Wallace River Hatchery broodstock collection actions directed at Chinook and coho salmon would be implemented. Natural-origin summer-run steelhead do not utilize the Wallace River for spawning, however, stray natural-origin summer-run steelhead may be encountered or affected at very low numbers during the periods when Wallace River Hatchery broodstock collection actions directed at Chinook and coho salmon would be implemented. Any natural-origin steelhead that are unintentionally captured during broodstock collection actions targeting Chinook salmon (up to 6 fish per year [WDFW unpublished hatchery rack reports, 2014]) would be immediately released. No natural-origin steelhead populations exist in Tulalip Bay tributaries where adult fall chum salmon and potentially Chinook salmon broodstock for the tribal programs would be collected.

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

<u>Negative effect (Genetic Diversity and Fitness) –</u>

The Wallace River Hatchery (WDFW 2013a) and Tulalip Hatchery (Tulalip 2012) Chinook salmon programs have the potential to result in some degree of genetic diversity change and fitness reduction in hatchery fish, and in the progeny of naturally spawning fish, relative to the baseline diversity and productivity status of the Skykomish and Snoqualmie Chinook salmon populations, as well as other Chinook salmon populations in Puget Sound. Here we consider three areas of genetic effects resulting from the Snohomish Chinook salmon programs: within population diversity reduction, outbreeding effects, and hatchery-influenced selection.

Within-population diversity - Because neither of the two Chinook salmon programs collects broodstock from the Snoqualmie population, they should have no impact on the within-population diversity of that population (although they may have other effects, as described below). Both the proposed Tulalip and WDFW Chinook salmon hatchery programs have some potential to reduce genetic diversity within the Skykomish Chinook salmon population as a consequence of artificial propagation. However, we consider this risk slight for several reasons. Use of natural-origin fish as broodstock is limited, as explained above, and the progeny of these fish, along with other returning hatchery fish, contribute to the population effective size. In addition, the relatively low contribution of hatchery fish to natural spawners makes the possibility of a Ryman-Laikre effect (Ryman and Laikre 1991), causing a serious reduction in effective size, very small. The most serious risk to overall diversity is the hatchery programs failing to maintain or increase the total Skykomish Chinook salmon population adult fish return abundance, however, this risk seems slight based on previous years of operations. As with any hatchery program, genetic diversity could be reduced if fish collected for broodstock do not reflect the Skykomish summer Chinook run at large in terms of migration timing, spatial distribution, age class, and sex ratio. However the program incorporates several management practices to address this risk. In addition, the program will employ matrix spawning (Busack and Knudsen 2007; Currens et al. 1998), which should further enhance effective size and maximize the possibility of individual fish contributing to the progeny generation. Best diversity-oriented management practices identified by the operators to be implemented for the Skykomish Chinook salmon program include:

- The indigenous hatchery- and natural-origin aggregations of the Skykomish Chinook salmon population would be used as the broodstock source for the hatchery programs.
- Natural-origin Skykomish Chinook salmon would be collected and incorporated into the hatchery broodstock to maintain diversity and reduce the risk of hatchery-influenced selection.
- Operation of the Wallace River Hatchery weir for the duration of the Chinook salmon migration period to remove hatchery-origin Chinook salmon returning to the lower river, consistent with achievement of annual MSG objectives
- Removal of natural-origin Chinook salmon for broodstock would be limited numerically and spatially to ensure that adequate numbers of fish are left in the river to spawn naturally, without being affected by artificial propagation. A minimum of 878 Chinook salmon escaping to the Wallace River each year would be retained in the lower river or released above the Wallace River weir to allow the fish to spawn naturally.
- A sufficient number of adult fish would be collected for use as broodstock each year to maintain a high effective breeding population size in the combined hatchery-natural population.
- Broodstock collected for the program would representative of the total run at large each year and contributions of broodstock to the propagated hatchery population are equalized as much as possible.
    - Broodstock would be collected randomly throughout the adult Skykomish summer Chinook salmon return period to the watershed (June through September at Wallace and June through October at Sunset Falls). This collection window reduces the risk of inadvertently including feral Green River-origin Chinook salmon in the broodstock.
    - Practices would be applied to help ensure that run/maturation timing, location, age, and sex ratio of the Chinook salmon population collected as broodstock each year are reflective of the total adult return for each year with regard to run timing, return location, age class, and sex ratio.
    - Run timing, return location, age class, and sex ratio data would be collected annually from the total returns and from fish collected as broodstock to monitor whether hatchery broodstock are reflective of the run-at-large.
    - Genetic, CWT, and otolith mark recovery data would be collected from adult fish spawning naturally and fish retained as broodstock for analysis to determine $pHOS_D$ and pNOB levels associated with the Chinook salmon programs.
- Mating strategies applied through the program help ensure that all fish collected have an equal opportunity to contribute to the production of progeny as a measure to retain the genetic diversity of the Chinook salmon population collected and spawned.
    - Random selection of adult fish for spawning as they ripen and representatively across the entire maturation time frame for the hatchery stock
    - Calculation of the proportion of ripe fish encountered (of the total estimated to be available for spawning) applied to the total egg-take goal would determine the egg-take for each day so that the gametes collected over the spawning period represent the span of maturation timing.
    - All males would be considered for spawning and chosen randomly and representatively on any spawning day

- Jack Chinook salmon would be incorporated into spawning at a rate of 2% of spawned males and
- Application of a factorial mating scheme with eggs pooled from five females equally spread into five buckets and fertilized with milt from one of five males. This procedure may also limit hatchery-influenced selection.

Overall, NMFS considers the risks posed by the Wallace River and Tulalip Chinook salmon programs to within-population diversity of the Snohomish Chinook salmon populations to be low to negligible.

Outbreeding effects –The genetic diversity of the Snohomish Chinook salmon populations could be adversely affected if the proposed hatchery programs for the species incorporated as broodstock Chinook salmon originated from other Puget Sound populations. Inter-mixing the Skykomish stock with other Puget Sound Chinook salmon populations could decrease genetic differences between, and uniqueness of, currently distinct, independent populations in the ESU. The risks are more of a concern for the Skykomish population as broodstock are not collected to support the Snoqualmie natural population. The two programs could also pose risk to other Puget Sound Chinook salmon populations if stray fish from these programs comprise a substantial portion of the natural spawners in those populations or of the broodstock in other programs which influence those populations.

The Wallace River Hatchery Chinook salmon stock was founded in the early 1970s from native Skykomish River summer Chinook that returned to the fish passage facility at Sunset Falls on the Skykomish River (Tulalip 2012; WDFW 2013a). The proposed Chinook salmon programs would be sustained only through the collection of broodstock from the adult population returning to the Skykomish River watershed, including the Wallace River and Sunset Falls Fishway (WDFW 2013a). The programs would continue to artificially propagate only the native Skykomish stock, represented by the hatchery- and natural-origin aggregations that have been shown to be genetically identical (WDFW 2013a, citing Marshall 1997; and PSTRT 2001). As mentioned above, broodstock for the Wallace River Hatchery program are currently selected representatively over the summer Chinook adult return timing at the Sunset Falls (June through October) and Wallace River Hatchery (June through September) adult trapping sites. Adult returns after September are excluded from collections to reduce the risk of including remnant Green River-lineage fall Chinook salmon adults in the broodstock (see Section 2.3.3 and Tulalip 2012 for a description of the discontinued fall Chinook salmon hatchery program). Skykomish stock origin of fish collected and incorporated as broodstock would be verified by early ("summer") adult return timing, and for hatchery-origin fish, presence of an identifying mark or tag that differentiates the fish from natural-origin Chinook salmon.

To examine in detail the potential for gene flow from other populations into the Snohomish Chinook salmon populations, NMFS (Haggerty 2017) examined CWT recoveries in the Snohomish River watershed for return years 2006 through 2015. This span of years was determined to best represent current patterns of straying that would likely occur for the two Chinook salmon programs operating in the action area. Within the Snohomish Basin, Chinook salmon CWTs were recovered from 19 different hatchery programs including the two action area programs. From 2006 through 2015, a total of 31,326 Chinook salmon are estimated to have spawned within the Skykomish Chinook salmon population's natural spawning areas, 8,975 of which were estimated to be of hatchery origin, for an estimated pHOS over the span of years examined of 28.7%. CWT expansions accounted for only 33% of these, suggesting there may be a large amount of error using this method to estimate proportionate pHOS contributions. No Tulalip Hatchery CWTs were recovered, however otolith mark analysis data suggest that Tulalip Hatchery-origin fish comprised 2.3% of the hatchery-origin fish spawning in the Skykomish River watershed. Based on CWT recoveries, the main contributor to the pHOS level observed in the Skykomish River watershed was the Wallace River Hatchery program (84%). The only notable out-of-basin contributor was the Soos Creek Hatchery (Green River) program (14%). Based on this estimated proportionate contribution, of that estimated pHOS of 28.7%, on average 4% may originate from the Soos Creek Hatchery program. Similar analysis of CWTs recovered at the Wallace River trap revealed that 99.8% of the fish were from the Wallace River Hatchery program.

In the Snoqualmie River watershed, CWTs were recovered from 16 different hatchery programs between 2006 through 2015. Over this time span, 13,380 Chinook salmon are estimated to have spawned within the Snoqualmie River watershed, and 2,532 were estimated to be of hatchery origin, for an estimated pHOS over for the years examined of 18.9%. CWT expansions accounted for only 48% of these, suggesting there may be a large amount of error using this method to estimate proportionate pHOS contributions. The pattern of hatchery program representation is much more diverse than that in the Skykomish River watershed. Both the Wallace and Tulalip programs contribute, but collectively account for only 22.7% of the pHOS. The major out-of-basin contributors were Soos Creek Hatchery (36.7%) and North Fork Stillaguamish Chinook salmon originating from releases from Whitehorse Ponds (20.7%). Several other hatchery programs contributed in non-negligible proportions. Assuming the recent Snoqualmie River watershed pHOS average of 20.4% (Table 7), this means that 4.5% can be attributed to the two Snohomish programs. That value may be considerably higher than the expected gene flow from these stray fish, given that the Skykomish Chinook salmon population spawns earlier than the Snoqualmie population. For these reasons, coupled with the attributable level of pHOS and considering the PRA tier 3 status of the Snoqualmie population, NMFS concludes that level of straying by Chinook salmon originating from the two Snohomish River basin programs poses little risk to the Snoqualmie Chinook salmon population.

The CWT results illustrating the contribution of strays from out-of-basin hatchery programs highlight the importance of using Skykomish broodstock for both Snohomish programs in conserving the genetic diversity of the two Snohomish River basin populations.

Data from Tulalip (2012) indicate that stray rates for adult Chinook salmon originating from the Tulalip Hatchery program are low relative to total terminal area adult returns. The average straying rate into the Snoqualmie River as a proportion of the average total Tulalip Hatchery-origin Chinook salmon terminal area return is 1.4%, or an average of 71 adult fish of the 2005-2011 average terminal area return of 4,898 fish (Tulalip 2012). Tribal and recreational fisheries directed at adult Chinook salmon returns to Tulalip Terminal Harvest Area harvest a majority of Tulalip Hatchery fish escaping to the action area (4,668 fish annual average for 2005-2011, or 95.3% of the average total Tulalip Hatchery terminal area return for the period [Tulalip 2012]). The vast majority of hatchery-origin Chinook salmon exhibit a high fidelity to their Tulalip Bay release location, and tribal fisheries in Tulalip Bay substantially reduce the number of adult hatchery-origin fish that could stray into the Snoqualmie River. Prior to converting from predominately non-native fall Chinook salmon broodstock, Tulalip Hatchery Chinook salmon composed 80.1 percent of the hatchery-origin fish on the Snoqualmie River basin natural spawning grounds (Tulalip Tribes, Unpublished Data, 2014).

Under the proposed HGMPs, a robust adult Chinook salmon escapement monitoring and biological sampling program would be conducted throughout the Snohomish River watershed each year to estimate gene flow resulting from hatchery-origin fish straying (see section 2.2.3 and 11.0 in Tulalip 2012; WDFW 2013a)[15]. As described in WDFW (2013a) and Tulalip (2012), the co-managers would continue to implement 100 percent marking and tagging (adipose fin clip and CWT combined) and 100 percent differential thermal otolith marking of all hatchery-origin Chinook salmon released each year, and monitor escapement throughout the Snohomish watershed to identify possible hatchery fish influence on natural spawning population genetic diversity. Tissue samples would be collected from natural- and hatchery-origin adult carcasses in natural spawning areas, hatchery broodstock, and juvenile Chinook salmon captured through smolt trapping or estuary beach seining. Genetic analyses of the samples would be used to identify and monitor gene flow and relative productivity within and between the Skykomish Chinook salmon hatchery population and the native Snoqualmie Chinook salmon population. Information gained would be used to adaptively manage the hatchery programs to reduce genetic diversity risks posed by hatchery- origin fish to the Snoqualmie Chinook salmon population.

The following measures would be implemented through the Wallace River Hatchery and Tulalip Hatchery Chinook salmon programs to reduce the risk of outbreeding effects to the Snohomish River watershed Chinook salmon populations:

- The proposed programs would continue to propagate and release only hatchery- and natural-origin fish identified by return timing, return location, and marks/tag presence/absence as part of the Skykomish Chinook salmon population.
- Measures would be implemented at the time of broodstock collection and spawning at Wallace River Hatchery to minimize incorporation out-of-basin strays into the gene pool. Adults collected as broodstock would be checked for the presence of marks or CWTs (all fish produced by the proposed programs for the species would be marked and/or tagged).
- Natural-origin Chinook salmon (identified by the presence of an adipose fin and the lack of a CWT) would only be collected as broodstock during the summer Chinook return period and in Skykomish stock critical habitat at the Sunset Falls Fishway and/or Wallace River traps.
- All juvenile fish released through the program would be marked with adipose fin clips and/or CWTs, and otolith marks to allow for annual monitoring and evaluation of straying and natural spawning by Wallace River Hatchery and Tulalip Hatchery Chinook salmon in Snohomish River basin areas where adult fish may potentially stray.
- Straying into adjacent watersheds where other natural-origin Chinook salmon populations exist, and gene flow between populations, would be monitored and analyzed through mark and tag recovery and tissue sampling for genetic analysis implemented at hatchery broodstock collection sites, through carcass recoveries during spawning ground surveys, and during juvenile outmigrant sampling programs.

[15] The HGMPs emphasize that funding for all proposed monitoring and research actions is contingent on availability. Monitoring and research funds provide wages for technicians and biologists who conduct the proposed actions and evaluate results. Budget reductions experienced by fish resource management entities in recent years have severely reduced funding to the agencies that have led to employee and program cutbacks. With an expected continuation of budget reductions for fisheries management programs in the Pacific Northwest, it may not be possible to implement the described actions necessary to fully monitor hatchery program performance and effects.

- To reduce the risk of straying, juvenile fish reared through the program would be adequately acclimated to their sites of release at Wallace River Hatchery and Tulalip Hatchery to encourage a high adult return fidelity to those release sites or their vicinity (e.g., Tulalip Bay).
- High harvest rate fisheries implemented by the Tulalip Tribes to remove adult hatchery-origin Chinook salmon returning to Tulalip Bay would reduce the number of Tulalip Hatchery-origin adult fish escaping to stray in Snohomish River basin natural spawning areas.

Hatchery-influenced Selection – As explained in Section 2.4.1, even though measures may be in place to conserve genetic diversity though inclusion of only fish from the appropriate stock, representation of the entire run timing, use of matrix spawning, and other hatchery management measures, there are differences between the environments experienced by hatchery- and natural-origin fish for a portion of their life history phases that can cause genetic changes that may potentially reduce the fitness of associated population(s) in the natural environment. This effect is termed hatchery-influenced selection. The major factors determining the effects of this selection are the 1) magnitude of differences between the environments the two types of fish experience considered over their entire life history, 2) the rate of gene flow between the two groups, and 3) the length of time the program has been in place. Currently, efforts to reduce the risk of hatchery-influenced selection are focused on the second factor: rates of gene flow. Guidelines for risk reduction have been widely disseminated through activities of the Hatchery Scientific Review Group (HSRG 2009; HSRG 2014). These guidelines have not been adopted by NMFS. The science regarding the subject is evolving, however, based on the best available science, NMFS assumes that programs meeting the HSRG guidelines provide adequate levels of risk reduction for hatchery-influenced selection, so for the purposes of this opinion, these guidelines will be considered in gauging potential effects of the proposed Chinook salmon hatchery programs. For this reason, and because the HGMPs reference the standing of the hatchery programs relative to the guidelines, we will address the HSRG guidelines first, and then address additional considerations related to hatchery-influenced selection.

The HSRG guidelines are based on demographic surrogates for gene flow: pNOB, pHOS, and PNI (the latter approximated by a function of the other two). As previously mentioned, the co-managers are actively involved in RM&E to develop better estimates of these parameters based on actual gene flow (described below), and use subscripts D and G to denote the demographic or genetic basis of the metric, respectively. We will follow this convention in this discussion.[16]

The Wallace River Hatchery program incorporates natural-origin fish from the Skykomish Chinook salmon population into its broodstock, and returning adults from the program spawn in nature with the Skykomish Chinook salmon population. This program is thus considered an integrated program under the HSRG guidelines. NMFS considers the Skykomish Chinook salmon population a PRA level 2 population, equivalent to a "contributing" population in the HSRG guidelines (HSRG 2009).

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[16] Although the effort to actually measure gene flow from hatchery programs rather than rely on a demographic surrogate represents a logical technical advance that NMFS enthusiastically supports, a caveat is necessary. pHOS, when used as a variable for consideration of genetic risk, along with pNOB and PNI, are assumed as indicators of gene flow. However, the model used to develop the guidelines (Ford 2002) does not explicitly incorporate gene flow. As a result, it is not clear that the genetically based estimates of pHOS, for example, should be regarded simply as more accurate versions of the demographically based ones. A new model may be necessary. In the meantime, NMFS will consider the genetically based estimates more accurate versions of the demographic ones.

The average hatchery-origin proportion of all naturally spawning Chinook salmon in the Skykomish River, during the most recent nine years for which data are available (2006-2014), is 27.8%, ranging from 16.7% to 46.0% (Tulalip 2012; WDFW 2013a; WDFW and Tulalip Tribes, unpublished spawning ground survey data). The pHOS metric is often viewed as a four-year average representing one Chinook salmon generation. Given low observed straying rates for Chinook salmon produced through the Tulalip Hatchery program, Chinook salmon returning through Wallace River Hatchery releases likely comprise the majority of hatchery-origin fish spawning naturally in the Skykomish River watershed, including the Wallace River where the fish are released. Nearly 63 percent of the total number of hatchery-origin Chinook salmon observed in all natural spawning grounds in the Skykomish River watershed were observed in just one tributary - the Wallace River (1997-2014 for years with available data). The escapement of hatchery-origin fish to natural spawning areas has been substantially reduced from previous years (1997-2001), when the annual proportion of hatchery-origin fish spawning naturally averaged 49.9 percent (range to 28.6% to 66.2%) (WDFW 2013a; Tulalip 2012).

The HSRG guideline for the Wallace River Chinook salmon program, based on population recovery importance (PRA level 2 = “contributing) is PNI ≥ 50%. The operators have established a PNI objective for the program. The PNI_D objective, based on demographic (carcass count) data to determine the number of hatchery-origin spawners in natural spawning areas, is currently 0.50, increasing to 0.7 resulting from implementation of BMPs that are part of the proposed actions, and assuming environmental conditions in freshwater and marine areas that are not detrimental to salmon survival and productivity (WDFW 2013a). As previously mentioned, the co-managers proposed use of actual genetic data rather than demographic data to derive PNI (PNI_G) and assess genetic risks to the natural population would likely lead to higher PNI estimates than derived demographically because not all hatchery-origin fish censused contribute to natural spawning. The PNI_D values presented here are therefore worst case indicators of hatchery fish genetic influence. These demographic data-based PNI_D objectives are considered levels that would increase the likelihood that the natural Skykomish population drives the genetic diversity status of the aggregate hatchery and natural-origin population. Based on demographic data-based estimates of the proportion of hatchery-origin fish spawning naturally, and considering realized natural-origin Chinook salmon broodstock incorporation levels, the average PNI_D for the program from 2006 through 2016 was 0.44 for the total Skykomish population, and 0.56 for the population excluding the Wallace River, where hatchery-origin Chinook home to their release location (Table 14).

The risk of hatchery-influenced selection from the Skykomish program may be lower than that expected by the estimated PNI value for two reasons. First, nearly all the empirical data collected to date on fitness loss estimated through relative reproductive success comes from stream-type salmonids with obligate yearling life histories (Berejikian and Ford 2004; Christie et al. 2014). Fish with shorter hatchery residence times may undergo less hatchery-influenced selection (RIST 2009). Most Puget Sound Chinook salmon, including all the fish released by the Tulalip Hatchery program and 2/3 of the fish released by the Wallace River program, are released as subyearlings. Understanding the relative selective influence of these two levels of hatchery residence is a critical research need. Second, the factorial mating scheme used in the Wallace River hatchery program may serve to help equalize family size, which should reduce selection response relative to mating systems that are less structured (Allendorf 1993). Even disregarding these considerations, however, the Skykomish Chinook programs appear to pose little risk to the Skykomish Chinook salmon population from hatchery-influenced selection.

A relative reproductive success (RRS) study (Spidle 2017) conducted in the Snohomish basin by the comanagers based on juvenile collections and spawners returning in 2011-2013 added support to the perception that the Wallace River is a less productive part of the basin. The Wallace basin offers a considerably different environment than the rest of the Snohomish basin, characterized by unnaturally low flows resulting in high temperatures that act as physical and thermal barriers to upstream migration and spawning. This results, in part, because neither stream at the hatchery is in its original stream channel and now runs an extra mile and interacts with different aquifers (M. Crewson, Tulalip Tribes, pers. comm., August, 2017). The RRS study concluded that overall, reproductive success in the Wallace was approximately half of that in the rest of the basin. Therefore, NMFS has agreed to exclude the Wallace escapement from pHOS estimates.

The RRS study found that the RRS of hatchery-origin spawners was only 43% and 54% of natural-origin spawners in the Skykomish and Snoqualmie basins, respectively. The operators feel that census pHOS levels should be adjusted by RRS, a concept promulgated by the HSRG (e.g., HSRG 2014). This concept, makes sense because the adjusted value may more accurately represent the reproductive output of the hatchery-origin spawners than the census number. However, as explained in Section 2.4.2.2, NMFS supports the adjustment only when it is clear that the RRS disparity is the result of environmental rather than genetic effects. This may be true in the case of the Snohomish study. The study is remarkable in that RRS deficits of this magnitude have been seen in only one other study in Chinook salmon - the Wenatchee River study (Williamson et al. 2010; Ford et al. 2012). In the Wenatchee study, a great deal of the RRS deficit appeared due to spawning location (Hughes and Murdoch 2017), arguing that an RRS adjustment might be appropriate in that case. The same may be true of the Snohomish study (Spidle 2017), but this is not clear at the current stage of analysis. Once additional analysis of the research is completed, a strong case for using the RRS adjustment may emerge, but for the time being NMFS will rely on the census pHOS levels for evaluation of genetic risk. However, given the fact that it may eventually be determined that the most accurate pHOS estimate is that which has been at least partially adjusted for RRS. In Table 14 we present both the pertinent adjusted (also called effective pHOS) and unadjusted pHOS as well as PNI values.

We would like to offer additional clarification. In the materials submitted to us, the operators used the widely publicized and commonly used adjustment for generating effective pHOS (e.g., HSRG 2014):

$$pHOSeff = rrs*pHOS$$

During our analysis, we determined that this equation was erroneous, and that the correct equation was:

$$pHOSeff = rrs*pHOS/(rrs*pHOS+(1-pHOS)$$

Table 14 uses the correct adjustment. At low pHOS levels the differences between the two equations are slight, but the difference can be quite large if pHOS is high.

Table 14. Genetic metrics pHOS and PNI calculated using demographic information for the Snohomish basin as well as values adjusted using the results of a co-manager conducted relative reproductive success (RRS) study. Values are shown comparing inclusion and exclusion of Wallace river spawners.

Brood Year	$pNOB_D$ Skykomish	$pHOS_D$ Skykomish	$pHOS_G$ Skykomish ($pHOS_D$ Scaled 0.4266 for RRS)	PNI_D Skykomish (Including Wallace)	PNI_G Skykomish (PNI_D Scaled 0.4266 for RRS)	$pHOS_D$ Skykomish (Excluding Wallace)	PNI_D Skykomish (Excluding Wallace)	$pHOS_G$ Skykomish (Excluding Wallace)	PNI_G Skykomish (Excluding Wallace)	$pHOS_D$ Snoqualmie (All Hatchery-Origin Fish)	$pHOS_G$ Snoqualmie ($pHOS_D$ Scaled 0.54 for RRS)
2006	0.32	0.17	0.08	0.66	0.80	0.09	0.78	0.05	0.86	0.17	0.10
2007	0.51	0.43	0.24	0.54	0.68	0.27	0.65	0.15	0.77	0.12	0.07
2008	0.40	0.18	0.08	0.69	0.82	0.04	0.91	0.02	0.95	0.14	0.08
2009	0.12	0.19	0.09	0.38	0.56	0.16	0.43	0.09	0.57	0.28	0.17
2010	0.24	0.27	0.14	0.47	0.63	0.16	0.60	0.09	0.73	0.11	0.06
2011	0.32	0.25	0.13	0.55	0.71	0.11	0.74	0.06	0.84	0.32	0.20
2012	0.34	0.34	0.18	0.50	0.65	0.27	0.56	0.15	0.69	0.35	0.22
2013	0.16	0.21	0.10	0.43	0.60	0.11	0.59	0.06	0.72	0.13	0.08
2014	0.12	0.46	0.27	0.21	0.31	0.33	0.27	0.18	0.39	0.17	0.10
2015	0.08	0.48	0.28	0.15	0.23	0.41	0.16	0.23	0.26	0.16	0.10
2016	0.17	0.38	0.20	0.31	0.45	0.20	0.46	0.11	0.60	0.26	0.16
Overall Arith. Mean:	**0.25**	**0.30**	**0.16**	**0.44**	**0.59**	**0.20**	**0.56**	**0.11**	**0.67**	**0.20**	**0.12**
Arith. Mean (Assessed <LAT)	**0.26**	**0.25**	**0.13**	**0.50**	**0.65**	**0.15**	**0.62**	**0.09**	**0.73**	**0.22**	**0.13**

 Omits 2007, 2011, 2013-2015 years where Skymomish population was assessed to be in critical status (<1,745 NOS).

Note, 2013 Skykomish NOS escapement was estimated in-season to be in critical status, but final NOS escapement was estimated to be 1,860 NOS.

An important element of the HGMPs is the level of genetic monitoring that would be implemented to allow tracking and evaluation of potential genetic risks posed by the proposed programs. Under the proposed actions, the genetic composition of fish produced in the hatchery- and the natural population of Skykomish Chinook salmon would be monitored and evaluated to assess PNI_G as an indicator of hatchery-influenced selection effects on Skykomish population diversity. The co-managers have proposed that genetic-based metrics - $PHOS_G$ and PNI_G - replace the demographic versions of these metrics. In their HGMPs, the co-managers indicate that these genetic-based metrics are more accurate estimators of the genetic interactions between hatchery- and natural-origin Chinook salmon than the demographic measures commonly in use.

Sampling and analyses are already underway to develop these indicators. Between return years 2011 and 2013, 12,169 juvenile fish and 604 adult Chinook salmon were collected, sampled and genotyped (Spidle 2017). DNA-based parentage assignment methods were developed to analyze these samples, and samples collected in the future, to estimate relative productivity and abundance, effective number of breeders (N_b), and effective population size (N_e) for naturally-spawning Chinook salmon by origin, sex, age and location. These methods provide preliminary measures of population genetic diversity and spatial distribution for comparison between years and to demographic-based estimates of $pHOS_D$ and PNI_D. The tissue samples were collected from natural- and hatchery-origin adult carcasses retrieved from natural spawning areas in the Skykomish River watershed, and from juvenile fish sampled from smolt traps were processed and analyzed to estimate gene flow between the naturally spawning hatchery aggregation and the Skykomish Chinook salmon natural population (Spidle 2017). Natural- and hatchery-origin adult carcasses from the Wallace River watershed, and juvenile Chinook salmon outmigrants collected through juvenile outmigrant trapping in the Skykomish River were also tissue sampled for DNA analyses.

Comparisons of $PHOS_D$, and preliminary $PHOS_G$ estimates for brood years 2011, 2012, and 2013 resulting from the aforementioned genetic analyses, are presented in Table 15. These preliminary results indicate that for these three brood years, hatchery-origin spawners produced roughly half as many juvenile outmigrants as natural-origin Skykomish and Snoqualmie Chinook salmon population spawners. It is unknown if the reduced number of migrants per spawner resulted from hatchery-origin fish spawning in poor locations (i.e., an environmental effect) or reduced fitness associated with domestication in the hatchery environment (i.e., a genetic effect) (Spidle 2017). Importantly, the relative reproductive success has only been measured by cohort, not generation, and only to the juvenile life stage, and the heritability of spawning success is unknown.

Table 15. Estimates of $pHOS_D$ (demographic) and $pHOS_G$ (genetic) obtained, respectively, by using just the observed ratio of carcasses attributed to hatchery- and natural-origin spawners from throughout the river basin or by scaling those estimates in accordance to their estimated reproductive success in that system (Source: Spidle 2017).

	2011	2012	2013
Skykomish $pHOS_D$	0.25	0.34	0.21
Skykomish $pHOS_G$	0.13	0.18	0.10
Snoqualmie $pHOS_D$	0.32	0.35	0.13
Snoqualmie $pHOS_G$	0.20	0.22	0.08

In conjunction with other viability assessments, these results presented in Table 15 will be used to adaptively manage the Chinook salmon hatchery programs by indicating whether hatchery management actions should be adjusted to improve the effectiveness of broodstock collection and integration methods, and control the proportion of hatchery-origin fish spawning naturally.

Broodstock used for the Tulalip Hatchery Chinook salmon program are from collections at Wallace River Hatchery, where natural-origin broodstock are integrated during spawning to sustain on-station fish releases. Continued annual infusion of the progeny of first generation spawners of integrated Skykomish stock-origin adults returning to Wallace River Hatchery serves as a means to reduce hatchery-influenced selection risks, relative to maintenance of production at Tulalip Hatchery following an isolated management approach lacking infusion of broodstock with natural-origin Skykomish Chinook salmon parentage. This type of genetic linkage diagrammatically is identical to what the HSRG calls a “stepping stone” system (HSRG 2014). Initial analysis by NMFS of programs connected this way shows that they pose considerably less risk of hatchery-influenced selection than programs that are not linked to a donor, natural-origin brood source (Busack 2015).

The Tulalip Hatchery program contributes to pHOS at a 2.3% level (based on otoliths) in natural spawning areas used by natural-origin Skykomish Chinook salmon within the Skykomish River watershed. Based on HSRG guidelines, and considering the “stepping stone” approach applied to sustain production, there is little risk to the Skykomish Chinook salmon population in terms of hatchery-influenced selection from returning Tulalip Hatchery fish escaping to spawn at a pHOS level of 2.3%.

<u>Negligible effect (Spawning ground competition and redd superimposition) -</u>

Another factor to consider is the potential for hatchery-origin adult salmon to adversely affect ESA-listed natural Chinook salmon and steelhead through competition for spawning sites and redd superimposition.

The proposed Wallace River Hatchery Chinook salmon program would be operated for harvest purposes. Although the intent is not to seed natural spawning areas, fish produced through the program are integrated with the natural population, and the hatchery population is included as part of the Skykomish Chinook population and the ESA-listed Puget Sound Chinook Salmon ESU. Measures are applied through the hatchery programs to help ensure that the hatchery component of the adult Skykomish Chinook salmon return remains largely the same as the natural component ecologically and genetically. The Skykomish watershed is under-seeded with naturally spawning Chinook salmon (see Section 2.2.1), and current hatchery-origin fish contribution levels to naturally spawning averages 27.8% of total escapement. Further, natural spawning by hatchery strays in the Skykomish watershed occurs mainly in the Wallace River, near the hatchery release site, and removed from the majority of natural Skykomish Chinook salmon spawning areas. Spawn timing differences between Wallace River Hatchery Chinook salmon (late summer-early fall) and Snoqualmie Chinook salmon (largely in the fall months) (see Table 16) reduce the risk that hatchery fish straying into the Snoqualmie River basin will interact with and substantially affect natural Chinook salmon. For these reasons, Wallace River Hatchery-origin Chinook salmon competition for spawning sites and redd superimposition by hatchery Chinook salmon are not threats to the Skykomish and Snoqualmie Chinook salmon populations.

Coho salmon adults originating from the Wallace River Hatchery program (on-station and Eagle Creek Hatchery releases) that escape to natural spawning areas are unlikely to compete with Chinook salmon for spawning sites or superimpose Chinook salmon redds because there is little temporal or spatial overlap between the two species (Table 16). The different species prefer different spawning conditions, and coho salmon adults straying from their Wallace River Hatchery release site have a later spawn-timing. The proposed hatchery program for coho salmon at Wallace River Hatchery would release 150,000 yearling smolts into the Wallace River each year (WDFW 2013b). The 2001-2005 brood year average smolt to adult return rate (measured as total survival to fisheries and escapement) is 5.97% (WDFW 2013b). Fishery contribution and escapement contribution data for brood year 2001-2005 indicate that 69% of surviving adult fish escape to Snohomish River basin hatchery release sites (WDFW 2013b, citing RMIS 2012). Assuming these survival and escapement rates for Wallace River Hatchery coho salmon program on-station releases, 6,000 adult fish could escape to Snohomish River basin freshwater areas each year, mainly to the hatchery release site, based on mark recovery data. The number of Wallace River Hatchery-origin coho salmon that would not return to the hatchery and instead escape into natural spawning areas where Chinook salmon redds may be present is unknown.

Table 16. Terminal area/river entry timing, spawn timing, and spawning location for natural-origin Snohomish River basin Chinook salmon, steelhead, and (Skykomish stock) coho salmon populations.

Species (Population)	Terminal Area/River Entry Timing	Spawn Timing	Spawning Locations
Chinook			
Skykomish	May - August	late-August - October	Skykomish R. & forks/ tribs.
Snoqualmie	August - October	Sept 15 - early-Nov	Snoqualmie R. and tribs.
Steelhead			
Winter-run	Nov - April	March- June 15	Skykomish & Snoqualmie basins
Summer-run	May - October	January - April	NF &SF Skykomish R.; Tolt R.
Coho salmon	Sept - early-Nov	Late-October - January	Skykomish R; Sky Forks; & tribs

Data sources: Haring 2002; WDFW 2002; WDFW spawning ground database (1998-2012).

In Washington watersheds, Chinook salmon generally excavate and deposit their eggs into deeper redds on average than do coho salmon (Devries 1997), reducing the risk of redd superimposition by naturally spawning hatchery-origin coho salmon. Chinook salmon on average select larger substrate (~35mm) for redd construction as compared to coho salmon (~20mm) (Quinn 2005). Coho salmon generally spawn in smaller streams than Chinook salmon (CDFG 2002). In addition, Wallace River Hatchery-origin coho salmon make up a small proportion of the total adult return of the species to the basin. From 2006-2012, escapement of Wallace River Hatchery-origin coho salmon has averaged 5.5% of the total basin escapement (Co-manager's Equilibrium Brood Database, 2014; WDFW and Tulalip Tribes, unpublished spawning ground escapement data, 2014). A 10 percent straying rate for Wallace River Hatchery-origin coho salmon onto the natural spawning grounds would result in approximately 0.5% of all coho salmon on the natural spawning grounds resulting from Wallace River Hatchery-origin strays. The coho salmon produced through the Wallace River Hatchery program return to and spawn predominately in the Wallace River sub-basin, and given the large amount of habitat available for spawning in the Skykomish River basin, the majority of Chinook salmon spawning areas in the Skykomish basin are not likely be affected by hatchery-origin stray coho salmon.

Because of a low total adult return level (20,000 smolts at 3.29% SAR equals 660 fish), and low expected stray rate (approximately 2% [WDFW 2013c]) of the total return, or 13 fish), adult coho salmon originating from Everett Bay Net-Pen releases would also not escape to Snohomish River basin tributaries in substantial numbers, and below levels of concern regarding these hazards.

Effects under the risk category for hatchery adult salmon returns from the three Tulalip tribal salmon hatchery programs would be negligible. Chinook, coho, and fall chum salmon produced by the Tulalip Tribes' hatchery programs are released outside of the Snohomish River freshwater areas. Mark recovery data indicate that tribal program-origin salmon produced in the Tulalip Creek watershed have a high return fidelity as adults to their Tulalip Bay release site, where high harvest rates in tribal net fisheries remove most returning adults. Fishery harvest rates on Tulalip hatchery-origin salmon would continue to be managed as close to 100% of the total terminal area return to Tulalip Bay as possible (Tulalip

2013a). Intensive tribal net fisheries target adult salmon returning to Tulalip Bay, and returning adult Chinook and coho salmon are not allowed to pass upstream into Tulalip Creek as a measure to maximize exposure of the fish to harvest. For example, estimated terminal area harvest rates on Tulalip Hatchery-origin coho salmon were 99% in 2007, 100% in 2008, 87% in 2009 and 100% in 2010 (Tulalip 2013a, citing State/Tribal RRTERM data). The majority of harvest for those years occurred in Tulalip Terminal Area Fishery (Area 8D). Straying by salmon from the tribal hatchery programs into adjacent Snohomish River basin freshwater areas occurs at low levels (e.g., for Tulalip Hatchery Chinook salmon, 0.6% of Skykomish Chinook salmon escapement and 2.6% of Snoqualmie Chinook salmon escapement) that would make any significant spawning ground competition and redd superimposition effects on Chinook salmon populations unlikely. Although the level of Tulalip hatchery-origin coho straying into the Snohomish River basin is likely low, the Tulalip Tribes propose that a marked/tagged adult coho salmon recovery program could be implemented in the basin to allow for enumeration of hatchery- and natural-origin fish components in total annual escapements, and as a means to evaluate straying (Tulalip 2013a).

None of the proposed hatchery programs would affect ESA-listed steelhead under this risk category, because the earlier return and spawn timing of hatchery-origin adult salmon precludes spawning ground interactions with the later spawning steelhead populations (Table 16).

<u>Beneficial effect (Population Viability) –</u>
In an evaluation of hatchery effects associated with implementation of its Hatchery Listing Policy (70 FR 37204, June 28, 2005), NMFS determined that fish produced through certain artificial propagation programs in the Puget Sound region may benefit particular viability parameters (McElhany et al. 2000) for specific populations included within ESA-listed salmon ESUs (70 FR 37204. June 28, 2005). Hatchery-origin populations determined to be no more than moderately diverged from reference natural-origin populations in the watersheds where the hatchery-origin fish were released were determined to impart varying degrees of benefits to the abundance, diversity, and spatial structure of natural salmon and steelhead populations. Chinook salmon that would be produced through the proposed Wallace River Hatchery (WDFW 2013a) and Tulalip Hatchery (Tulalip 2012) programs are considered to be no more than moderately diverged from their associated natural-origin Skykomish Chinook population that serves as donor broodstock for the programs (70 FR 37160). The ESA-listed hatchery-origin fish produced by the WDFW and Tulalip programs may therefore impart benefits to varying degrees to the abundance, diversity, and spatial structure of the Skykomish Chinook salmon population, but unlikely for its productivity, for the following reasons.

Abundance - One benefit potentially conferred by hatcheries is that they can be used, contingent on containing genetic resources included in an ESU or DPS, to boost the number of fish that spawn naturally. This can be particularly useful and important for conservation purposes, when freshwater habitat-related factors limit the survival and productivity of a natural population. A proportion of returning adult fish from the hatchery releases spawn naturally, producing natural-origin progeny that would, in turn, return as adults to spawn naturally. Short-term success in increasing the number of natural-origin, naturally spawning fish has been demonstrated for certain hatchery programs. Examples include Hood Canal summer chum salmon and reintroduction programs for Chimacum Creek (WDFW and PNPTT 2000; PNPTT and WDFW 2007); Lake Ozette sockeye salmon supplementation of Umbrella Creek (Makah Fisheries Management 2010); Hamma Hamma winter-run steelhead (Berejikian et al. 2008); and purposeful release of stray, mainly Issaquah Hatchery-origin Chinook salmon upstream of Landsburg Dam in the Cedar River (Anderson et al. 2012). However, natural populations that rely on artificial propagation are not viable (McElhany 2000) and success in increasing natural-origin fish abundance depends not on supportive breeding but on addressing factors for decline, including commensurate improvements in the condition and productivity of natural habitat (WDFW and PNPTT 2000; California HSRG 2012; Rawson and Crewson 2017).

The proposed WDFW and Tulalip Tribal Chinook salmon hatchery programs would be implemented for harvest purposes. However, as noted previously, a proportion of the adult fish returning each year stray into natural spawning areas in the Skykomish River watershed. Assuming continuation of a recent year average (2006-2014) contribution rate to natural spawning in the Skykomish River watershed by hatchery-origin Chinook salmon of 27.8% (Table 7), and an average annual total natural spawning escapement of 3,210 fish (Table 2.2.2.6 in WDFW 2013a), juvenile fish production levels proposed by the programs could potentially lead to the annual natural spawning escapement of 892 hatchery-origin adult Chinook salmon in the Skykomish River watershed. As already discussed, BMPs at the hatchery have integrated these fish with the local natural Chinook salmon population. Assuming recent year hatchery escapement levels, up to 3,790 (range: 1,903 to 6,221) (Puget Sound Chinook Run Reconstruction, January 23, 2013, WDFW unpublished data) hatchery-origin adult Skykomish stock Chinook salmon could return to the Wallace River Hatchery release location each year for use as broodstock to sustain the hatchery program or to seed natural spawning areas (WDFW 2013a).

Diversity – In addition to increasing the total number of returning adult salmon, hatcheries can also benefit population and ESU genetic diversity. Due to the poor status of natural populations in a watershed, genetic resources important to an ESU may reside in a hatchery program that was developed using the natural population as the donor. In 2005, NMFS determined that salmon and steelhead produced by all conservation hatchery programs and several harvest augmentation programs in the Puget Sound region should be included as part of the ESA-listed salmon ESUs and steelhead DPSs. In making this determination, NMFS reviewed the classification of all West Coast salmonid hatchery programs, taking into consideration the origin for each hatchery stock, the location of release of hatchery fish, and the degree of known or inferred genetic divergence between the hatchery stock and the local natural population(s) (81 FR 72759, October 16, 2016). Criteria in NMFS' Policy on the Consideration of Hatchery-Origin Fish in Endangered Species Act Listing Determinations for Pacific Salmon and Steelhead (''Hatchery Listing Policy'') (70 FR 37204, June 28, 2005) were used to guide this most recent review of the hatchery programs. The Hatchery Listing Policy states that hatchery stocks will be considered part of an ESU/DPS if they exhibit a level of genetic divergence relative to the local natural population(s) that is not more than what occurs within the ESU/DPS. NMFS also found that hatchery fish included as part of the ESA-listed salmon ESUs and steelhead DPSs served as genetic reserves and a brood source for rebuilding extant natural-origin salmon and steelhead populations residing in the watersheds (70 FR 37160. June 28, 2005). Among the hatchery Chinook salmon populations included as part of the ESA-listed Puget Sound Chinook salmon ESU are fish produced through the Wallace River Hatchery and Tulalip Hatchery programs.

The proposed hatchery Chinook salmon programs could benefit the diversity of the native Skykomish Chinook population by serving as a genetic reserve while critical habitat remains degraded, and as the habitat is restored. Applying BMPs to preserve the diversity of the propagated aggregation and reduce the risk of its divergence from the natural population, the hatchery programs would preserve genetic resources for the Skykomish population until prospects for its survival in the wild at a self-sustaining and viable state improve. Increased smolt emigration and adult fish returns afforded by the hatchery program over levels achievable by the natural-origin population under current habitat conditions would help ensure the Skykomish population is retained to the point where local adaptation and creation of a self-sustaining population, without the need for hatchery fish, would be achieved.

Spatial Structure – Hatchery programs with fish that are integrated with the local natural population and included in an ESU or DPS can contribute to increased spatial structure. Through acclimation of fish to unused or under-seeded habitat, and through density dependent effects, such programs can expand salmon population spawning and rearing distribution within a watershed.

Chinook salmon from the proposed Wallace River and Tulalip hatchery programs would benefit spatial structure of the native Skykomish population in the Wallace River as fish home to their release site. Although not an intent of the programs, fish straying from the hatchery release locations would contribute to Skykomish population spatial structure through natural spawning in other watershed tributaries. One objective is to return adult fish to the Wallace River Hatchery facility through on-station smolt releases to provide broodstock, and as necessary based on natural-origin Chinook salmon return levels, seed the lower and upper Wallace River with naturally spawning fish. The preference would be to rely on natural-origin fish, but in some years, hatchery-origin Chinook salmon would be used to help meet the MSG for the Wallace River. The MSG is pursued as a means to ensure that the Wallace River is adequately seeded with naturally spawning fish in available habitat as a means to foster increased returns of natural-origin Skykomish Chinook salmon (Tulalip 2012). Chinook salmon recruiting to Wallace River Hatchery in excess of annual hatchery broodstock needs may be returned to the stream in a 3:2 male: female ratio to achieve the MSG. MSG numbers of adult Chinook salmon by sex, for the Wallace River are 303 male and 202 female spawners in the lower Wallace River, and 224 and 149 males and females in the upper river. Hatchery-origin fish may be returned to the river in excess of MSG goals, subject to achievement of pHOS and PNI objectives for controlling genetic risks (WDFW 2013a). For these reasons, the proposed Chinook salmon hatchery program would likely benefit Skykomish Chinook salmon population spatial structure. However, as discussed in the section addressing within population diversity risks, there are concerns regarding potential adverse genetic effects on the Skykomish population related to MSG management in the Wallace River. Upstream passage of fish in excess of MSG goals would be expected to increase the potential for adverse genetic effects.

Productivity – Hatchery production of salmon in and of itself generally does not benefit natural salmon population productivity. Decades of straying by hatchery-origin fish in Puget Sound have not been associated with commensurate, observed increases in the productivity of any natural-origin Puget Sound Chinook salmon populations (NMFS 2004c). However, degraded habitat in the region cannot be dismissed as a primary causative factor suppressing naturally spawning hatchery and natural-origin Chinook salmon population productivity (NMFS 2010b; Judge 2011). While acknowledging that the condition of available habitat plays a primary role in determining naturally spawning fish productivity, as described in Section 2.4.1, the productivity of natural salmonid populations may be further impaired by spawning and genetic introgression from certain hatchery-origin fish species and life history types and at certain proportions of total naturally spawning population abundances. Self-sustaining natural production and natural productivity of several Hood Canal summer-run chum salmon populations introduced through hatchery-based supportive breeding into streams where the race of the species had become extirpated has been restored over the short term (PNPTT and WDFW 2007), but prospects for retention of the populations as self-sustaining over the longer term are unknown. Recent studies have indicated that Chinook salmon originating from hatchery programs can contribute positively to natural productivity for the species (Hess et al. 2012; Anderson et al. 2012; Ford et al. 2012). Based on current data, the contribution (positive or negative) of hatchery production to Skykomish Chinook productivity is unknown.

<u>Negligible effect – Marine-derived nutrients –</u>
Listed Chinook salmon and steelhead in the Snohomish River basin would benefit from the deposition of hatchery program-origin salmon carcasses resulting from straying (inadvertent natural escapement and spawning), and Chinook and coho salmon carcass distribution after spawning at the hatcheries. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase productivity in the Snohomish River basin, providing food resources for naturally produced Chinook salmon and steelhead (WDFW 2013a). Diminished numbers of salmonids returning to spawn in most Puget Sound watersheds have resulted in nutrient deficiencies compared to historic conditions, affecting salmon and steelhead productivity potential. Adult salmon and steelhead spawning escapements have significantly declined to a fraction of their historic abundance in many watersheds, raising concerns about a lack of marine-derived nutrients returning back to the systems in the form of salmon carcasses.

The historical amounts of nutrients available to streams in the Snohomish River basin derived from salmon carcasses was likely large and contributed to the enhancement of many forms of aquatic life (WDFW 2013a). The return of marine-derived nutrients (particularly nitrogen and phosphorous) from salmon carcasses provides an important nutrient source, particularly to the oligotrophic waters and riparian areas in the higher elevations of the Snohomish River watershed (Haring 2002). The basin has healthy returns of anadromous salmonid spawners relative to other Puget Sound areas, in particular coho salmon, but the ability of upper watershed areas to retain marine-derived nutrients from spawned salmon may be compromised by degraded riverine habitat, potentially resulting in carcasses being washed out before imparting any nutrient benefits (Haring 2002).

Natural spawning by stray hatchery-origin fish, and hatchery carcass seeding that would be implemented for a portion of annual adult returns through the Wallace River Hatchery coho salmon program (WDFW 2013b), would benefit marine derived nutrient deposition in the Snohomish River basin. However, the carcass biomass contributed by the hatchery programs would not be as significant compared with marine-derived nutrient input afforded by carcasses from naturally-spawning, natural-origin salmon and steelhead, which comprise the majority of the spawners.

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

<u>Negligible effect: Fish disease pathogen transfer and amplification –</u>
Best hatchery management practices that would be implemented to address fish health are described in each of the six Snohomish River basin salmon HGMPs. Fish health protection and maintenance measures, and hatchery sanitation procedures would be applied during the salmon broodstock collection, mating, incubation, rearing, and release phases of the proposed programs. Proposed measures and procedures are described in performance standards and indicators, adult management, and fish rearing

and release sections of each plan. Proposed fish health monitoring and evaluation measures are also described in those HGMP sections.

The hatchery programs would be operated in compliance with "The Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State" protocols (NWIFC and WDFW 2006). The co-manager policy delineates Fish Health Management Zones and defines inter and intra-zone transfer policies and guidelines for eggs and fish that are designed to limit the spread of fish pathogens between and within watersheds (NWIFC and WDFW 2006). The proposed hatchery programs would implement standard methods for the prevention, diagnosis, treatment, and control of infectious fish pathogens and BMPs for standard hatchery maintenance and sanitation practices as referenced in the co-manager's fish health policy (as per PNFHPC [1989] and AFS [1994) guidelines] to reduce the risk of fish pathogen amplification and disease transfer within the hatchery and to fish in the natural environment. For all salmon propagated through the Snohomish River basin salmon hatchery programs, fish health specialists and pathologists from the WDFW Fish Health Section and the Northwest Indian Fisheries Commission (NWIFC) would provide fish health management support and diagnostic fish health services. Following is a summary of fish health management procedures that would be applied during operation of the salmon hatchery programs.

Minimally invasive fish health maintenance procedures would be conducted during the periods when adult salmon collected as broodstock would be held at the hatcheries before they are spawned. Behavior and external condition of the fish would be routinely observed by hatchery staff, and non-lethal sampling would be conducted as needed to observe gross external condition in conjunction with standard fish handling (e.g., broodstock sorting). Any fresh, pre-spawning salmon mortalities would be removed from holding ponds and examined. If necropsy is warranted, the carcass would be either examined immediately by fish health staff (if present on-site), retained fresh, or frozen and examined during the next fish health professional monitoring visit (depending on how soon that will be possible). At the time of annual spawning, 60 adult salmon would be sampled from each of the total populations held. Samples would be analyzed for pathogens and parasites at the co-manager fish health labs. The health of propagated salmon would be monitored by hatchery staffs throughout the juvenile fish rearing periods at the hatcheries. WDFW and NWIFC fish health professional staff would visit the hatchery fish rearing sites monthly, or as needed, to perform routine monitoring of juvenile fish, advise hatchery staff on pathogen findings and disease diagnoses, and recommend remedial or preventative treatments through administration of therapeutic and prophylactic treatments when appropriate. Vaccinations of rearing fish populations to reduce the incidence of specific fish diseases would also be provided, as needed. Consistent with the co-manager fish health policy, representative samples of from the hatcheries would be examined for the presence/absence of infectious fish pathogens before they are released. The co-managers maintain a fish health database to identify trends in fish health and disease at the hatcheries. Fish health management plans for each facility would be assembled and implemented based on health and disease incidence trend findings.

Implementation as proposed of BMPs specified in the co-managers' fish health policy for monitoring the health of fish in hatcheries would reduce the likelihood of disease transmission from Snohomish River basin hatchery salmon to natural populations of salmon and steelhead. When implemented, those practices would help contain any fish disease outbreaks in the hatcheries, minimize the release of infected fish from hatcheries, and reduce the risks of disease transfer and amplification to natural populations (NMFS 2012b). BMPs applied to minimize risks of adverse effects on ESA-listed Chinook salmon and steelhead associated with fish disease pathogen transfer and amplification for the six proposed salmon HGMPs are based on best available science, and are expected to be sufficiently protective of ESA-listed natural populations and hatchery- origin fish. Further, high egg-to-smolt survival rates for fish propagated in the proposed hatchery programs, as reported in sections 9.1.1 and 9.2.1 of the HGMPs for Wallace River Hatchery and the Tulalip hatchery programs, indicate that protocols for monitoring and addressing the health of fish in hatcheries have been successful in containing disease outbreaks, minimizing the release of fish carrying infectious pathogens and reducing the risk of transferring disease to natural populations. For these reasons, fish pathogen and disease transmission and amplification risks that would be associated with HGMP implementation appear to be adequately addressed and minimized.

Negligible effect: Competition

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

All juvenile salmon produced through the Tulalip Tribes' salmon hatchery programs would be released as smolts or fry into Tulalip Bay watershed freshwater areas lacking ESA-listed fish from a natural population. Coho salmon yearlings from the Everett Bay Net-pen program would be released directly into seawater. There would therefore be no resource competition risks to ESA-listed fish in freshwater areas within the action area associated with Tulalip tribal Chinook, coho, and fall chum salmon, and Everett Bay Net-Pen coho salmon, releases.

The Wallace River, on which Wallace River Hatchery is located at RM 4.0, is tributary to the Skykomish River at RM 35.7, and smolts released through the WDFW Chinook and coho salmon programs at the hatchery must travel a minimum of 39.7 miles to reach Puget Sound. Coho salmon smolts released from Eagle Creek Hatchery must travel a minimum of 28.3 miles from their freshwater release point to reach seawater. The 28.3 to 39.7 miles of freshwater habitat the hatchery-origin fish released from these programs must transit during their seaward migration presents opportunities for interactions, and competition with, any rearing and emigrating fish from natural populations occupying the same freshwater habitat. The degree to which hatchery fish and fish from natural populations interact in these freshwater areas, potentially leading to competition effects, depends on temporal overlap between the two groups, considering emigration timing (Table 17) and emigration speeds. The relative sizes of juvenile hatchery salmon and fish from natural populations and size-determined diet preference differences) and their relative densities in migration reaches, would also determine competition risks in freshwater areas where the groups overlap spatially and temporally.

Table 17. Comparative individual sizes and freshwater occurrence timings for rearing and/or emigrating fish from natural populations of by species and life stage, and hatchery-origin salmon juveniles proposed for release from the Snohomish River basin hatchery programs.

Species/Origin	***Life Stage***	***Individual Size (mm FL avg. and range)***	***Occurrence or Release Timing***
Chinook salmon (wild)	Fry	*40 (35-67)*	*Mid-February - April*
Chinook salmon (wild)	Parr-Subyrlg.	*64 (39-95)*	*May - June*
Chinook salmon (wild)	Yearling	*103 (78-179)*	*Mid-March - mid-May*
Chinook salmon (hatchery)	Sub-yearling	*83 (57-103)*	*June*
Chinook salmon (hatchery)	Yearling	*181 (155-196)*	*April*
Steelhead (wild)	Fry	*60 (23-100)*	*June - Oct.*
Steelhead (wild)	Parr	*96 (65-131)*	*Oct.- mid May*
Steelhead (wild)	Smolt	*165 (109-215)*	*late April - June*
Coho (wild)	Fry	*30 (29-36)*	*February - March*
Coho (wild)	Parr	*56 (37-70)*	*April - April*
Coho (wild)	Yearling	*95 (70-150)*	*May - June*
Coho (hatchery)	Yearling	*140 (131-156)*	*May and June*
Chum (wild)	Fry	*38 (33-50)*	*March - May*
Chum (hatchery)	Fed Fry	*56 (50-65)*	*April - mid May*
Pink (wild)	Fry	*34 (32-43)*	*March - April*

- Wild Chinook salmon data from Beamer et al. 2005 (yearling data), and Tulalip Tribes juvenile out-migrant trapping reports for the Skykomish River (average individual fish size, size range, and emigration timing data from Nelson et al. 2003; Nelson and Kelder 2005a; Nelson and Kelder 2005b).
- Wild steelhead individual size data and occurrence estimates from Shapovalov and Taft (1954) and WDFW juvenile out-migrant trapping reports (Volkhardt et al. 2006a; 2006b; Kinsel et al. 2008).
- Wild coho data for Skykomish River from Nelson and Kelder 2005b (smolts); Beachum and Murray 1990 and Sandercock 1991 (fry); parr size range extrapolated from smolt and fry data considering year-round residence.
- Wild chum data from Volkhardt et al. 2006a (Green River fall-run), and Tynan 1997 (Hood Canal summer-run).
- Wild pink salmon data from Topping and Kishimoto 2008 (Dungeness River pink salmon).
- Hatchery-origin fish release size and timing data are average individual fish size and standard release timing targets proposed in the Wallace River Hatchery and Tulalip Hatchery salmon HGMPs, and average size and size range data for regional hatcheries from WDFW and PNPTT 2000 (estimated mm fish lengths converted from fish per pound data using conversion tables in Piper et al. 1982.

Adverse resource competition effects on natural Chinook salmon and steelhead natural populations associated with Wallace River Hatchery yearling Chinook and coho salmon, and Eagle Creek Hatchery coho salmon releases are unlikely because of substantial size and hence prey differences (SIWG 1984) between the hatchery yearlings and fish from the natural populations that would be encountered in watershed areas when and where the hatchery-origin fish are released. Steward and Bjornn (1990) concluded that hatchery-origin fish maintained under propagation for an extended period prior to release as smolts (e.g., yearling Chinook and coho salmon) may have different food and habitat preferences that reduces the potential for competition during their seaward migration. All fish produced by the programs for release in the watershed would be released as seawater-ready fish (smolts or fry) as a measure to foster rapid emigration seaward, and clearance from watershed areas where they may compete with fish from natural populations. Based on Skykomish River smolt trap data collected from 2006 through 2014, peak captures of Wallace River Hatchery-origin yearling Chinook salmon in the lower Skykomish River occurred (on average) 13.2 days after their release (Matt Pouley, Tulalip Tribes, personal communication, October 2014). This trapping data-based average demonstrates the tendency for newly released hatchery yearling smolts to emigrate downstream rapidly, and disperse into lower watershed areas. In 2001, WDFW reduced the number of yearling coho salmon released from Wallace River Hatchery from 300,000 fish to the currently proposed 150,000 fish level as a further ecological risk reduction measure.

Two-thirds of Chinook salmon produced through the Wallace River Hatchery Chinook salmon program would be released as sub-yearling smolts in June, after the majority of juvenile Chinook salmon and steelhead have emigrated seaward (Table 17). Release of subyearling Chinook salmon in late-spring is designed to minimize temporal overlap and interactions with juvenile listed fish, and the opportunity for substantial competition effects from the hatchery-origin subyearling Chinook salmon release component. Because of their relatively small individual size and June release timing that substantially reduces spatial and temporal overlap with emigrating natural-origin salmon and steelhead, Wallace River Hatchery subyearling Chinook salmon are unlikely to have substantial adverse freshwater ecological effects on listed juvenile natural-origin fish. Yearling Chinook and coho salmon would be released from Wallace River Hatchery in April and May, respectively. Eagle Creek Hatchery coho salmon smolts would be released in early April. Coho salmon released from these two programs would potentially commingle with any emigrating or rearing natural Chinook salmon and steelhead juveniles present downstream of the hatchery and approaching the estuary. While differences in diet and habitat preference make competition unlikely, as a further measure to reduce the risk of competitive interactions in the lower watershed, Wallace River Hatchery yearling coho salmon releases would be delayed until May each year.

As described in the HGMPs, the individual size and timing of all salmonids by origin, and spatial and temporal overlap between hatchery-origin juvenile out-migrants and fish from the local natural populations have been monitored by the Tulalip Tribes annually through smolt trapping since 2001 (e.g., Nelson et al. 2003, Nelson and Kelder 2005a and 2005b; Kubo et al. 2013). These annual juvenile out-migrant studies have provided data regarding the level of potential interactions between hatchery-origin Chinook and coho salmon released from Wallace River Hatchery and fish from natural populations of Chinook salmon in Snohomish River basin areas. The monitoring program is authorized through a separate ESA consultation process and trapping will continue as a means to identify the potential for adverse ecological effects, and the need to revise yearling salmon release practices to further reduce risks to fish from the local natural populations.

The co-managers have included hatchery management measures in the HGMPs designed to reduce freshwater competition between hatchery fish and fish from natural populations:

- Juvenile chum salmon produced through the Tulalip Tribes' programs would be released into freshwater habitat (immediately upstream from Tulalip Bay) where no natural populations of Chinook salmon and steelhead are present.
- Tulalip Hatchery Chinook and coho, and Everett Bay Net-Pen coho salmon would be released directly into marine waters.
- All sub-yearling Chinook salmon, yearling Chinook salmon, and yearling coho salmon would be released from Wallace River Hatchery as readily migrating fish, in a physiological condition ready for transition to a seawater existence. The practice of releasing only actively migrating smolts that would exit freshwater rapidly would reduce the duration of interaction with Chinook salmon or steelhead in the Snohomish River basin of a life stage vulnerable to competition for food or space.
- All Wallace River Hatchery coho salmon yearlings will be released in May, at night. Coho salmon yearlings produced by the Wallace River Hatchery and Eagle Creek Hatchery programs would be released immediately after a freshet. These release protocols would foster rapid seaward immigration.
- Hatchery and natural population emigration timing and abundance would be monitored each year through operation of the Tulalip Tribes' juvenile outmigrant trapping program to evaluate whether hatchery juvenile release timings pose a risk of substantial harmful ecological interactions. Alternate hatchery fish release timings or other mitigation measures would be developed to minimize such interactions.

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

The risk of hatchery-origin smolt predation on juvenile fish in freshwater is dependent upon three factors: 1) the hatchery fish and their prey must overlap temporally; 2) the hatchery fish and their prey must overlap spatially; and, 3) the prey should be less than 1/3 the length of the predatory fish. Table 17 compares the relative individual sizes and freshwater occurrence timings for emigrating juvenile Chinook salmon and steelhead in the Snohomish basin and hatchery-origin Chinook and coho salmon juveniles released through the proposed WDFW and Tulalip tribal programs. The hatchery-origin species and life stages with substantial spatial and temporal overlap with smaller juvenile ESA-listed Chinook salmon, posing the highest risk for predator-prey interactions, would be yearling Chinook and coho salmon. Subyearling Chinook salmon are released from Wallace River Hatchery after the majority of fish from the natural Chinook salmon populations have emigrated seaward, and the risk of interactions that would lead to predation is unsubstantial. Additionally, hatchery-origin subyearling Chinook salmon are too small in individual size to consume any co-occurring salmonids of life stages that would be present in downstream areas during June. A risk for predation for Wallace River Hatchery Chinook and coho salmon yearling releases is assigned based on the upper watershed release location (RM 4.0 in the Wallace River which enters the Skykomish River/Snohomish River at RM 35.7), and large individual fish size relative to the size of juvenile Chinook salmon from the natural populations that may be encountered during the spring release periods for the hatchery-origin fish. The same risk exists for yearling coho salmon released from Eagle Creek Hatchery at RM 28.3. The yearling Chinook and coho salmon produced at the two sites would not encounter juvenile steelhead of individual sizes vulnerable to predation, as young-of-the-year steelhead fry emerge later in the season and higher in the watershed, and are present as larger (yearling) parr in migration reaches used by the hatchery yearlings months after the yearlings would be released. Only large rearing yearling steelhead parr, and emigrating two-year old steelhead smolts, that are similar in size to the hatchery-origin yearlings, would be present in freshwater areas downstream of the Wallace River Hatchery and Eagle Creek Hatchery release sites. Steelhead at these life stages are too large in individual size to be vulnerable to predation by Wallace River Hatchery Chinook and coho salmon yearlings and Eagle Creek Hatchery coho salmon yearlings (Table 17).

As mentioned above, salmon produced through the Tulalip Tribes' salmon hatchery programs would be released as smolts or fry into Tulalip Bay or at RM 0.1 on Battle Creek where no ESA-listed salmonid populations occur. Coho salmon yearlings from the Everett Bay Net-pen program would be released directly into seawater. There would therefore be no predation risks to ESA-listed fish in freshwater areas within the action area associated with Tulalip Tribal Chinook, coho, and fall chum salmon, and Everett Bay Net-Pen coho salmon releases.

Chinook salmon yearlings released from Wallace River Hatchery would be of large enough average size (181 mm fl) to prey on other juvenile Chinook salmon that have been shown to average 41 mm (fl) (range 32-68 mm) (size range data from Nelson and Kelder 2005b) in April, when the hatchery yearlings would be released. Hatchery-origin coho salmon yearlings would be released at an average individual size of 140 mm (fl) in May. Emigrating and rearing Chinook salmon from natural populations in the Snohomish River basin that are present in watershed reaches downstream of Wallace River Hatchery and Eagle Creek Hatchery during the April-May yearling coho salmon release period average approximately 53 mm in individual size (range 32-88 mm fl) (Kubo et al. 2013). Chinook salmon fry and parr below this average fish size would be at risk of predation by the hatchery yearling coho salmon released from Wallace River Hatchery and Eagle Creek Hatchery. The risk of predation would be attenuated to a degree by the expected rapid downstream seaward emigration behavior of newly released hatchery-origin smolts. Although review of relative fish size and co-occurrence data, and information from other Pacific Northwest watersheds (e.g., Flagg et al. 2000) would indicate a risk of predation, diet studies from other Puget Sound watersheds indicate that newly released hatchery-origin yearling salmonids are not piscivorous. Stomach content analyses of hatchery-origin yearling coho salmon sampled near the mouth of the Elwha River in 1996, 2006, and 2007 showed no sign of piscivorous behavior (Peters 1996; Duda et al. 2011). Seiler et al. (2002) reported none of the yearling Chinook salmon sampled for stomach contents at WDFW's Green River smolt trap in 2000 had consumed co-occurring juvenile Chinook salmon. Topping and Kishimoto (2008) reported none of the hatchery-origin, yearling Chinook salmon sampled (n = 168) for stomach contents at WDFW's Dungeness River smolt trap in 2006 had consumed any fish.

To reduce predation risks, all yearling Chinook and coho salmon released from Wallace River Hatchery and Eagle Creek Hatchery would be seawater-ready smolts, propagated using methods to ensure that the fish are of uniform, large size that would ensure the fish are physiologically ready to emigrate downstream, without delay, and not residualize in freshwater. Downstream smolt trapping data in the Skykomish River (Nelson et al. 2003; Nelson and Kelder 2005b) indicates that newly released Wallace River Hatchery yearling Chinook and coho salmon migrate seaward rapidly, with the majority passing the trapping location in less than three weeks (21 days). From 2006 through 2014 the average outmigration period beyond the smolt trap on the Skykomish River for Wallace River Hatchery-origin Chinook salmon averaged 13.2 days (this is the average number of days from the last hatchery fish released, to the last hatchery fish trapped in the smolt trap); ranging from 5 to 30 days (Matt Pouley, personal communication, October 2014). A substantial number of yearling coho salmon force-released from Wallace River Hatchery (watershed RM 39.7) on May 6, 2003 were recorded at the Tulalip Tribes' juvenile out-migrant trap at Skykomish RM 23 on the day of release, with no hatchery yearlings observed migrating past the trapping location 14 days post-release (data from Nelson and Kelder 2005b). From 2006 through 2014, the average outmigration rate beyond the smolt trap on the Skykomish River for Wallace River Hatchery-origin coho salmon averaged 12.7 days post-release, ranging from 5 to 22 days (Matt Pouley, personal communication, October 2014).

In a review of available literature on predation by hatchery-origin yearling salmonids on juvenile salmonids from natural populations, Naman and Sharpe (2012) concluded that managers can effectively minimize predation by reducing temporal and spatial overlap between the two groups. The proposed Wallace River Hatchery programs for yearling Chinook and coho salmon would reduce temporal and spatial overlap and the potential for predation on ESA-listed juvenile salmon and steelhead through application of the following measures:

- All Chinook and coho salmon yearlings would be released in April and May, usually immediately after a freshet (when possible), to foster rapid seaward emigration, reducing the duration for interactions with co-occurring juvenile Chinook salmon of sizes vulnerable to predation.
- All hatchery-origin Chinook salmon yearlings would be released as migration-ready smolts that would move downstream rapidly to the estuary where they would disperse seaward.
- Juvenile out-migrant monitoring (permitted for listed fish takes through a separate ESA consultation) would continue in the Skykomish River watershed and in the Snohomish River estuary to determine annual salmonid size and timing by fish origin, and to identify spatial and temporal overlap among natural salmonid populations in the Snohomish basin and hatchery-origin juvenile out-migrants.
- If monitoring information suggests that proposed release timings for yearling Chinook salmon and coho salmon from the hatcheries would result in predation on fish from natural populations in the Snohomish River basin, alternate release timings or other mitigation measures would be developed to minimize such interactions.

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

<u>Negligible effect –</u>
Juvenile hatchery-origin salmon that would be released to emigrate into estuarine and marine waters within and adjacent to the action area each year have the potential to adversely affect natural populations of Chinook salmon and steelhead through competition and predation. As juvenile salmon released from the proposed programs arrive in the estuary, they may compete with other Chinook salmon and steelhead in areas where they co-occur, if shared resources are limiting. The hatchery-origin salmon may also prey on natural fish of sizes vulnerable to consumption. Effects may be more pronounced in nearshore marine waters adjacent to river mouths where hatchery-origin salmon may initially be concentrated. Interactions and effects likely diminish as the fish disperse into the main body of the Puget Sound and into the Pacific Ocean.

Regarding competition effects in estuarine and marine waters, the main limiting resource for Chinook salmon and steelhead that could be affected through competition posed by hatchery-origin fish is food. The early estuarine and nearshore marine life stage, when juvenile fish have recently entered the estuary and populations are concentrated in a relatively small area, is a critical life history period during which there may be short term instances where food is in short supply, and growth and survival declines as a result (SIWG 1984; Duffy 2003; Pearcy and McKinnell 2007). The degree to which food is limiting depends upon the density of prey species. This does not discount limitations in available food resources in more seaward areas as a result of competition, as data are available that suggests that marine survival rates for salmon are density dependent, and thus possibly a reflection of the amount of food available (SIWG 1984; Brodeur 1991; Holt et al. 2008). Researchers have looked for evidence that marine area carrying capacity can limit salmonid survival (Beamish et al. 1997; HSRG 2004). Some evidence suggests density-dependence in the abundance of returning adult salmonids (Emlen et al. 1990; Lichatowich 1993; Bradford 1995), associated with cyclic ocean productivity (Nickelson 1986; Beamish and Bouillon 1993; Beamish et al. 1997). Collectively, these studies indicate that competition for limited food resources in the marine environment may affect survival (also see Brodeur et al. 2003). The possibility that large-scale hatchery production could exacerbate density dependent effects in the ocean, particularly when ocean productivity is low, deserves consideration. For example, Puget Sound origin salmon survival may be intermittently limited by competition with almost entirely natural-origin odd-year pink salmon originating from Puget Sound and the Fraser River watersheds (Ruggerone and Goetz 2004), particularly when ocean productivity is low (Nickelson 1986; Beamish and Bouillon 1993; Beamish et al. 1997; Mahnken et al. 1998).

Complicating any assessment of the marine area predation and competition effects of hatchery-origin Chinook salmon production is that the temporal distribution, trophic interactions, and marine area limiting factors for Puget Sound Chinook salmon populations in marine waters are poorly understood (Duffy 2003). Assessment of the effects of hatchery Chinook salmon on natural populations of Chinook salmon in Puget Sound is problematic because there is a lack of basic information about what shoreline habitats are used by Chinook salmon and whether this nearshore life stage contributes significantly to growth and survival through subsequent life stages (Fresh 2006). There is also an absence of information regarding the carrying capacity of Puget Sound for juvenile Chinook salmon on which to base analyses of food resource competition risks. Naish et al. (2008) could find no systematic, controlled study of the effects of density on wild salmon, or of interactions between wild and hatchery salmon, nor on the duration of estuarine residence and survival of salmon. Further complicating any assessment of ecological effects are observed natural cycles and fluctuations in the carrying capacity of marine environments. The Puget Sound marine ecosystem was until recently believed to be stable, internally regulated and largely deterministic. The current view is that Puget Sound is dynamic with much environmental stochasticity and ecological uncertainty (Mahnken et al. 1998; Francis 2002).

For these reasons, it is difficult to make judgments regarding the carrying capacity of Puget Sound and the Pacific Ocean, and whether there are any ecological effects associated with hatchery-origin salmon production that are adversely affecting salmon and steelhead productivity and survival, particularly when natural populations are contributing few fish toward any carrying capacity level. The limited information available is insufficient to identify the source of any ecological interactions and limiting factors, for example which species might be responsible for density dependent interactions let alone which hatchery or hatcheries, and consequently what remedies are likely to be effective. Assigning marine area ecological and demographic effects specifically for hatchery-origin salmon production from any individual Puget Sound region (e.g., the Snohomish River basin) would be speculative, since hatchery-origin fish intermingle at the point of ocean entry with natural populations and other hatchery fish from many other Pacific Northwest regions. At best, it can be said that, during years of limited food supply, juvenile fish survival and size may be reduced, and this is true with or without hatchery-origin fish. Hatchery enhancement of salmon populations could exacerbate density-dependent effects during years of low ocean productivity. However, there are no studies that demonstrate or suggest, the magnitude of hatchery salmon smolt release numbers in Puget Sound that might be associated with adverse changes in natural population Chinook salmon survival rates in the estuary, the Puget Sound, or in the Pacific Ocean.

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

Evidence indicates that all Chinook salmon populations in the ESU may rear throughout Puget Sound for varying periods of time (Duffy 2003; Fresh 2006; WDFW, unpublished data 2008). Juvenile Chinook salmon may rear in Puget Sound for one to seven weeks, but some fish may become resident in the Sound and remain there until maturity (commonly called “blackmouth”) (Simenstad et al. 1982). Recent studies indicate that, upon release, substantial fractions (approximately 30%) of most hatchery stocks of Chinook salmon adopt the blackmouth life history strategy (Chamberlin et al. 2011; O’Neill and West 2009). The period in which competition may be a risk factor may be extended if hatchery and natural Chinook salmon aggregations use Puget Sound estuarine waters for an extended time to rear or migrate (e.g., if both hatchery and other Chinook salmon residualize as blackmouth in Puget Sound). Conversely, the risk of competition may be short in duration if the hatchery and other Chinook salmon are actively migrating seaward, into areas where the fish may disperse more widely and where food resources may be more plentiful.

In Puget Sound, hatchery-origin Chinook salmon have the greatest potential for dietary overlap with comparably sized Chinook and coho salmon. Chinook salmon have the most diverse diets of salmon species studied in Puget Sound marine areas, feeding largely on neustonic and drift insects, as well as larval and juvenile fishes as the fish migrate into and grow in the pelagic zone (Duffy 2003).

Regarding predation risks posed by hatchery-origin Chinook and coho salmon in estuary and marine areas, NOAA Fisheries (2002) concluded that predation by hatchery-origin fish on smolts or sub-adults is less likely to occur than predation on younger life stages in freshwater. Chinook salmon, after entering the marine environment, generally prey upon fish one-half their length or less and consume, on average, fish prey that is less than one-fifth of their length (Brodeur 1991). During early marine life, predation on Chinook salmon will likely be highest in situations where large, yearling-sized hatchery fish encounter fry (SIWG 1984). Studies by Seiler et al (2002) have shown that the individual sizes of Chinook salmon successfully transitioning to the marine environment are too large for predation by co-occurring hatchery-origin fish. Likely reasons for apparent low predation rates on Chinook salmon juveniles by larger Chinook salmon are described by Cardwell and Fresh (1979). These reasons included: 1) due to rapid growth, natural Chinook salmon are better able to elude predators and are accessible to a smaller proportion of predators due to size alone; 2) because Chinook salmon have dispersed, they are present in low densities relative to other fish; and 3) there has either been learning or selection for some predator avoidance. In a literature review of Chinook salmon food habits and feeding ecology in Pacific Northwest marine waters, Buckley (1999) concluded that cannibalism and intra-generic predation by Chinook salmon are rare events. However, based on indirect calculations, Beauchamp and Duffy (2011) estimated that if cannibalism did occur, older Chinook salmon (>300 mm FL; blackmouth) during June-August could potentially consume 6 to 59 percent of age-0 juvenile Chinook salmon recruiting into marine waters in the Puget Sound, depending on whether a very conservative estimate (6% Chinook in diet) or reasoned assumptions (20% Chinook in diet in May and June then allowed to decline daily via linear interpolation) were used.

Competition for food resources in Puget Sound marine areas between hatchery-origin fall chum salmon released into Tulalip Bay through the Tulalip Tribes' Battle Creek Hatchery program and Chinook salmon and steelhead is not likely a substantial risk factor. Spatial and temporal differences in emigration behaviors and residence time in Puget Sound between Chinook salmon, steelhead, and the fall chum salmon (fed fry) life stage produced in the tribal program (SIWG 1982; Duffy 2003; Fresh 2006), and partitioning of available food resources in marine areas (Duffy 2003, Brodeur et al. 2007) limit the risk of any substantial competition effects. Regarding predation risks, chum salmon fry released through the Tulalip hatchery program are physically too small in individual size to consume Chinook salmon and steelhead present in marine areas where fall chum salmon may interact with those species (Table 17).

Co-occurrence and interactions between hatchery-origin and other juvenile salmonids in the Snohomish River estuary, nearshore marine areas, and pocket estuaries have been monitored for the past decade (WDFW 2013a, citing Tulalip Tribes and NOAA Fisheries unpublished data, Mindy Rowse and Casey Rice, NOAA Fisheries; Todd Zackey Tulalip Tribes 2001-2012). The data have not indicated substantive predation or competition effects caused by Wallace River Hatchery and Tulalip Hatchery-origin salmon releases. This may be because temporal overlap between hatchery-origin salmon and other Chinook salmon in the Snohomish River estuary appears to be of a very short duration, particularly for hatchery-origin yearlings, which apparently disperse into pelagic waters soon after entering seawater (Rowse and Fresh 2003; Beamer et al. 2006). Although also short in estuarine residence duration (Rowse and Fresh 2003), sub-yearling hatchery-origin Chinook salmon are present for a longer period than hatchery-origin Chinook salmon yearlings, increasing the potential for ecological interactions with other Chinook salmon. Release of hatchery-origin subyearlings from the proposed Wallace River Hatchery program in June each year, two months after the majority of juvenile Chinook salmon from the local natural population have emigrated seaward, would reduce the risks of interactions between the groups, and hatchery-related effects.

Hatchery-origin salmon predation effects on steelhead in the Snohomish River estuary are unlikely, due to the large size of steelhead smolts relative to the co-occurring hatchery salmon (Table 17), which precludes consumption. Substantial hatchery salmon-related competition effects on steelhead in the estuary are also unlikely. Hatchery-origin Chinook salmon yearlings (Fresh 2006) and steelhead (Moore et al. 2010) smolts tend to disperse into the pelagic waters of the Salish Sea soon after entering seawater, limiting the duration of interactions, and the potential for food resource competition between the groups in nearshore areas where they may co-occur and are most concentrated. Hatchery-origin Chinook salmon subyearlings have been shown to use the estuary for a similarly short period, although for a more extended period than yearling Chinook salmon. Subyearling Chinook salmon tend to use nearshore habitat areas that are not preferred by the much larger steelhead smolts, which may also have different diet preferences because of their larger size. This partitioning of estuary and marine areas reduces the likelihood that hatchery-origin subyearling Chinook salmon would pose substantial competition risks to steelhead in marine waters.

The proposed Snohomish River basin hatchery salmon programs would lead to unsubstantial changes in the total number of anadromous salmonids encountered by ESA-listed species in Puget Sound and Pacific Coastal marine waters outside of the basin. For example, the total numbers of juvenile Chinook salmon that would be released through the Wallace River Hatchery and Tulalip Hatchery programs are 3.4 million subyearlings and 500,000 yearlings. This level of annual production would be 8.5% of the 46.1 million hatchery-origin Chinook salmon released in Puget Sound each year. Snohomish River basin hatchery-origin salmon would commingle in marine waters with juvenile salmonids from many regions and other hatcheries (e.g., Fraser River; Columbia River; Washington Coast; and Puget Sound), making their contributions to total juvenile abundance inconsequential.

An additional consideration bearing on estuary and marine area effects of the hatchery programs on natural salmonids is that the actual number of juvenile hatchery fish that survive to reach the ocean would be substantially less than the number proposed for release into freshwater through the hatchery programs. Exposure to natural conditions, including predation by piscivorous fish, bird, and mammal species, leads to high levels of mortality to juvenile hatchery-origin fish immediately upon their release into the natural environment and before the fish reach seawater. Seiler et al. (2001; 2002; 2003) and Volkhardt et al (2006) used comparative recovery rate data for hatchery-origin spring, summer, and fall sub-yearling Chinook salmon released 24, 57, 78, and 89 miles upstream of Skagit River juvenile out-migrant traps positioned at river mile 17 to estimate their survival rates during downstream migration. They reported that from 37% to 80% of hatchery-produced Chinook salmon released in upstream areas survived the downstream journey to migrate past the traps. In years when flows were conducive to juvenile emigration, apparent survival rates generally were higher (Volkhardt et al. 2006). Data collected through annual juvenile out-migrant trapping studies in the Green River indicate that 10.6% of Chinook salmon yearlings, and 13% to 70% of yearling steelhead, released from upstream hatcheries survived to reach the RM 33 trapping location (Seiler et al. 2004). These studies indicate that less hatchery salmon than the maximum levels proposed for release will actually survive to encounter and potentially compete with or prey on natural fish in the estuary and marine areas within and adjacent to the action area.

The number of adult fish produced by the proposed hatchery actions would also represent an unsubstantial proportion of the total abundance of each species present in Puget Sound and in Pacific Coastal marine areas. As shown in Table 18, the recent year (2000-2011) average total annual return to Puget Sound of Skykomish stock hatchery-origin Chinook salmon was 7,966 fish, or 3.5% of the total Puget Sound run size of the species for the entire region. For comparison to the average Snohomish basin hatchery-origin and total Puget Sound Chinook salmon adult returns, the estimated total annual ocean abundance for Chinook salmon from all Pacific Northwest region watersheds (including British Columbia) averages approximately 1,000,000 fish, of which 0.8% would be Snohomish Basin hatchery-origin fish (L. LaVoy, NMFS, pers. comm., January 6, 2012). Coho salmon produced largely by the Wallace River and Tulalip Hatchery programs contribute an annual average of 43,798 fish, or 5.2% of the total average Puget Sound return of the species. The fall chum salmon fry release program operated by the Tulalip Tribes has produced a recent year (2000-2008) average adult chum salmon return to Puget Sound of 88,011 fish, or 4.4% of the total average run-size for the species/race. At the proposed 12.0 million fed fry release level (Tulalip 2013b), and assuming a fry survival rate to Puget Sound adult return of 1%, the Battle Creek fall chum salmon program would return 120,000 fish to Puget Sound each year, or 6.0% of the total average return for the species for 2000-2008.

Table 18. Average total adult returns of Snohomish River basin hatchery-origin Chinook, coho, and fall chum salmon to Puget Sound compared with the total adult returns from all Puget Sound areas.

Species	Average Puget Sound Adult Return of Snohomish Basin Hatchery-Origin Fish	Average Total Puget Sound Adult Return	Snohomish Basin Hatchery-Origin Salmon Percent of Total Puget Sound Adult Return
Chinook salmon	7,966[1/]	231,038[1/]	3.5%
Coho salmon	43,798[2/]	837,405[2/]	5.2%
Fall chum salmon	88,011[3/]	1,985,985[3/]	4.4%

1/ Estimated total terminal area adult return of hatchery-origin Skykomish stock Chinook salmon, and for all Chinook salmon in Puget Sound for 2000-2011 from WDFW run reconstruction, January 23, 2013.
2/ Puget Sound terminal area run size data for 2000-2011 from WDFW run reconstruction, J. Haymes, WDFW, pers. comm., January 7, 2013.
3/ Puget Sound fall chum salmon run reconstruction data for total terminal area adult returns for 2000-2008 from K. Adicks, WDFW, pers. comm., January, 2010.

For the above reasons, NMFS does not believe it is possible to meaningfully measure, detect, or evaluate the specific effects of Snohomish River basin hatchery-origin juvenile and adult salmon production on ESA-listed species in Puget Sound and in the Pacific Ocean.

2.4.2.5 Research, monitoring, and evaluation

Negligible effect –
The proposed hatchery program actions address the five factors that NMFS takes into account to analyze and weigh the beneficial and negative effects of hatchery effects-related research, monitoring, and evaluation (RM&E) (see Section 2.4.1.5). As expected, the programs include RM&E to monitor compliance with this opinion and to inform future decisions regarding how the hatchery programs can make adjustments that further reduce risks to ESA-listed Snohomish River basin Chinook salmon and steelhead. What is more, the RM&E included in the HGMPs analyzed in this biological opinion is expected to lead to a better understanding of the status of ESA-listed species in the Snohomish River basin and what is affecting them. Data gathered through the RM&E activities will greatly supplement best available information regarding how to help recover ESA-listed Chinook salmon and steelhead. Negligible lethal and sub-lethal effects on listed species are expected to occur as a result of implementing RM&E actions.

The six HGMPs include RM&E actions designed to identify the performance of the programs in meeting their fisheries harvest augmentation objectives and to minimize adverse effects on ESA- fish. Specific RM&E actions for the six HGMPs are described in section 1.10 and section 11.0 of each hatchery plan. Although monitoring the benefits of the programs to fisheries harvest through effective hatchery production of juvenile fish to ensure harvestable returns of adult fish is an important objective (e.g., smolt to adult survival rate and fishery contribution level monitoring), all of the Snohomish River basin hatchery salmon programs include extensive RM&E and adaptive management measures designed to monitor and address hatchery-related effects on natural populations of fish. In particular, the co-managers propose to continue to monitor interactions between juvenile hatchery fish and other salmonids in freshwater, estuarine, and marine areas within the region to evaluate and manage program ecological effects. Another important action is monitoring and management of the number and proportions of the total escapements of hatchery-origin adults returning to the hatcheries and escaping to basin tributaries. This monitoring action includes collecting tissues from natural- and hatchery-origin spawners and outmigrants for DNA analysis to assess genetic composition of the composite spawning population and genetically-effective $pHOS_G$ and PNI_G. These demographic and genetic data are used as a means to monitor, determine the effects of, and manage gene flow associated with hatchery-origin fish spawning in the natural environment.

The Tulalip Tribes and WDFW would continue their collaboration on monitoring and biological sampling of juvenile salmonids in the Skykomish and Snoqualmie rivers through juvenile out-migrant trapping in the watershed, and through seining in adjacent estuarine and nearshore marine areas. The co-managers are also collaborating in the proposed continuation of the Sentinel Stock Genetic Mark Recapture Project and a concurrent Relative Reproductive Success Project, which would benefit Chinook salmon escapement and productivity evaluations (Tulalip 2012). These monitoring programs would provide information for hatchery-origin fish and natural populations regarding temporal and spatial co-occurrence, juvenile outmigration timing, fish size, habitat utilization, prey consumption, and other important metrics and data used to assess the potential for any adverse ecological and genetic interactions between hatchery fish and natural populations of Chinook salmon and other species of juvenile salmonids. The proposed adult escapement monitoring program (stream surveys and biological sampling) would be conducted annually to document: $pHOS_D$; spawning contribution and straying rates;

and derive methods to estimate gene flow; and relative genetically effective abundance, productivity, spatial structure, diversity, age, sex, and size of natural- and hatchery-origin Chinook escaping to natural spawning areas and the hatcheries in the Snohomish River basin (Tulalip 2012). The co-managers will use this information to verify compliance with the HGMPs and to inform and advise adaptive management of the programs to meet performance criteria in the HGMPs. In addition, they intend to use the genetic based techniques when developed to inform and advise adaptive management of the programs relative to the effects of habitat condition and harvest actions affecting the natural populations in the Snohomish basin.

Specific actions described in the HGMPs would include monitoring of salmon escapement to the Snohomish River basin natural spawning areas and hatcheries. All juvenile fish released through the programs would be marked, tagged, and/or fin clipped to allow for their differentiation from natural-origin salmon, after their release from the hatcheries and when the fish return as adults to Snohomish River basin marine and freshwater areas. All Chinook salmon released through the Wallace River Hatchery and Tulalip Hatchery programs would be differentially otolith-marked by hatchery of origin and brood year. The majority of the fish would receive adipose fin clips, but sub-groups of Chinook subyearlings released through both programs would be alternatively marked with a CWT/adipose fin clip combination or CWT only as part of DIT groups. Similar to Chinook salmon, all coho salmon released from Wallace River Hatchery would receive an adipose fin clip only, an adipose fin clip/CWT combination, or CWT only (DIT group). All yearling coho salmon released into Tulalip Bay through the Tulalip Hatchery program would be marked with an adipose fin clip, with an additional 50,000 also receiving a CWT and all would be differentially otolith-marked by hatchery of origin and brood year. Eagle Creek Hatchery and Everett Bay Net-Pen coho salmon smolts would also be mass-marked with an adipose fin clip. All chum salmon fry released through the Battle Creek Pond program would receive a thermally induced otolith mark. Annual mark and tag recovery programs in U.S. and Canadian marine and freshwater fishing areas, in combination with thermal mark recovery in natural spawning areas, terminal fisheries, and at hatcheries would be used to identify hatchery-origin fish. These hatchery-origin fish recovery data would be used to estimate total fisheries contribution and escapement for Snohomish River basin hatchery salmon production.

The ability to identify hatchery-origin fish would allow for appropriate monitoring of the performance and effects of the hatchery programs in meeting their harvest augmentation objectives, while minimizing risks to listed fish in the Snohomish basin region. Recovery of marked or tagged hatchery-origin salmon would allow for estimation of the number of clipped, tagged, and thermally-marked fish escaping to basin streams each year. Foot and boat spawning ground surveys would count spawning fish and sample carcasses for scales, otoliths, adipose-fin clips, CWT's, and tissues for DNA analysis. The same level and types of biological sampling would occur for fish escaping to the hatcheries and collected as broodstock.

Juvenile outmigrant trapping is also proposed using rotary screw traps in the Skykomish and Snoqualmie systems, and seines and fyke nets in estuarine areas, and seines in nearshore marine areas, to provide important information on the co-occurrence, out-migration timing, relative abundances and relative sizes of co-occurring hatchery-origin fish, ESA-listed natural populations of Chinook salmon and steelhead, and non-listed natural-origin coho, chum, and pink salmon. Data collected through operation of the Tulalip Tribes' juvenile out-migrant traps in the lower Skykomish and Snoqualmie rivers would allow assessment of emigrating natural- and hatchery-origin fish abundance and overlap in timing between natural-origin species and newly released hatchery-origin fish. Other data collected at the trap that would be used to assess hatchery effects are fish size, origin (marked/tagged vs. unmarked/untagged), and other biological data (e.g., tissues sampled for genetic analyses). To ensure proper care and maintenance of trapped fish as a means to minimize take of ESA-listed fish, the traps would be checked frequently to reduce holding duration, and trapping would be suspended during high flow events to reduce the risk of fish injury and mortality. Other risk aversion measures that would be implemented to minimize take are specified in annual NMFS 4(d) Evaluation and Determination documents authorizing tribal research in Puget Sound (NMFS 2017a). Up to 32,000 adipose fin clipped subyearling Chinook salmon would be retained from the hatcheries each year for use in juvenile outmigrant trap efficiency trials. Under the 4(d) rule for ESA-listed Puget Sound Chinook salmon, hatchery-origin Chinook salmon that are included as part of the ESU, but are marked with an adipose fin clip, are exempt from ESA take prohibitions (65 FR 42422, July 10, 2000, as amended 70 FR 37160, June 28, 2005).

As previously authorized through a separate ESA consultation, WDFW's Wild Salmon Production/Evaluation Unit, in collaboration with the Tulalip Tribes, would continue to conduct a genetic mark recapture study in the Snohomish basin to improve spawning escapement estimates, and to evaluate the relative contribution of hatchery-origin Chinook salmon to natural production calculated from genetic data. The Sentinel Stocks Project, combined with a concurrent Relative Gene Flow Project would analyze tissues collected from Chinook salmon smolts from the Tulalip Tribes' juvenile out-migrant traps, and tissues collected from adult fish on the spawning grounds, to determine contributions to natural production by fish origin and parentage. The Wallace River Hatchery HGMPs require completion and distribution of an annual report describing RM&E activities and results (WDFW 2013a).

Other effects of the proposed hatchery salmon programs on ESA-listed salmon and steelhead populations would also be monitored and considered with other habitat- and harvest-related effects. These actions would help determine whether the programs were harming juvenile and adult Chinook salmon or steelhead as a result of operation of the hatcheries, collection of broodstock, and the production of juvenile fish that would return as adults. In general, actions taken at the hatcheries to meet this objective would include monitoring of water withdrawal and effluent discharge to ensure compliance with permitted levels; monitoring of broodstock collection, egg take, fish survival rates, and smolt release levels for each program to determine compliance with program goals; and fish health monitoring and reporting in compliance with "The Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State" (NWIFC and WDFW 2006).

2.4.2.6 Operation, maintenance, and construction of hatchery facilities

<u>Negative to negligible effect –</u>

Effects on ESA-listed fish from operation and maintenance activities associated with the proposed hatchery programs would range from negative (screening at Wallace River Hatchery) to negligible (effluent discharge at all hatchery facilities). There would be no new construction included in the proposed actions, so there would be no listed fish effects from new construction for hatchery purposes.

As acknowledged in the Wallace River Hatchery HGMPs (WDFW 2013a; 2013b), that while hatchery water intake screens on the Wallace River and May Creek are in compliance with state and federal guidelines (NMFS 1995, 1996), they have not been updated to meet the most recent NMFS Anadromous Salmonid Passage Facility Design Criteria (NMFS 2011c). WDFW has indicated the intent in their HGMPs to modify screening at Wallace River Hatchery to comply with these criteria. Intake screens on both tributaries are scheduled by WDFW for rebuild by fall 2020 to bring the screens into compliance with those criteria. Proposed retrofitting of the Wallace River Hatchery screens will reduce risks to ESA-listed Chinook salmon and steelhead in the Wallace River watershed. Screening at the Tulalip Tribes' hatchery facilities and Eagle Creek Hatchery is not a risk factor, as there are no listed fish populations present in the small tributaries where the facilities are located. The Everett Bay Net-Pen program would operate using mesh sizes on the net-pen containing hatchery-origin coho salmon smolts (WDFW 2013c) that do not pose any measurable risks of entrainment and mortality to listed fish in marine waters.

Four of the salmon hatchery facilities use surface water exclusively (Wallace River Hatchery; Tulalip Creek Ponds, Battle Creek Pond, and Eagle Creek Hatchery); one facility uses a combination of groundwater and surface water (Tulalip Hatchery); and one facility relies on passive tidal flow of marine water for fish rearing (Everett Bay Net-Pen). All water withdrawn for use in the freshwater fish rearing locations would be returned to surface waters in close proximity to the point of withdrawal or impoundment. Surface water used for incubation and fish rearing at Wallace River Hatchery would be pumped from the Wallace River and May Creek. The facility has permitted water rights to withdraw up to 12,000 gallons per minute (gpm) from the Wallace River and up to 800 gpm from May Creek.

No ESA-listed Chinook salmon originate above the hatchery in May Creek, and withdrawal of water up to permitted levels from the Wallace River would not lead to dewatering between the water withdrawal and discharge points that would lead to substantial effects on listed fish migration, spawning, and rearing. Up to 100 percent of the surface water in the East Fork and West Fork of Tulalip Creek would be impounded for use in fish rearing for the Tulalip Hatchery and Tulalip Creek Ponds programs. Up to 100% of the flow in Battle Creek would also be impounded for rearing chum salmon fry through the Tulalip Tribes' Battle Creek Pond program. Both locations are in compliance with state water right permits issued for the programs. The wells at Tulalip Hatchery supplying groundwater to support the tribal summer Chinook and coho salmon programs are located on tribal Trust lands, and are therefore under the regulatory purview of the Tulalip Tribes regarding limits and permitted withdrawal levels. However, withdrawal of groundwater up to the proposed level (1.6 cfs - Tulalip 2012) would have no effect on listed fish.

No listed fish are present in the Tulalip Bay tributaries where the Tulalip Tribes' Chinook, coho, and chum salmon hatchery programs are located (Tulalip Creek, West Fork Tulalip Creek and Battle Creek), so there would be no effects of surface or groundwater withdrawal on listed fish populations. Eagle Creek Hatchery would withdraw 0.7 to 0.9 cfs of water from Eagle Creek, a spring fed tributary. Water withdrawn to support coho salmon rearing at Eagle Creek Hatchery would not affect listed fish, as no Chinook salmon or steelhead populations are present in the creek. The Everett Bay Net-Pen program uses seawater, passively supplied through tidal flow, for rearing coho salmon. The amount coursing through the net-pen is not measurable relative to the total amount of water in the Puget Sound, and no effects on listed salmon or steelhead are expected. In summary, withdrawal of surface and groundwater for use in the hatchery programs would have no substantial effect on listed fish in the watershed. All water used by the hatcheries would be returned to the watercourses near the points of withdrawal. No stream reaches would be dewatered to the extent that listed natural fish population migration spawning, and rearing would be impaired, and there would be no net loss in river or tributary flow volume.

The direct discharge of hatchery facility and marine net-pen effluent is regulated by the Environmental Protection Agency (EPA) under the Clean Water Act through National Pollutant Discharge Elimination System (NPDES) permits. For discharges from hatcheries not located on Federal or tribal lands within Washington, the EPA has delegated its regulatory oversight to the State. Washington Department of Ecology issues and enforces NPDES permits that ensure water quality standards for surface and marine waters remain consistent with public health and enjoyment, and the propagation and protection of fish, shellfish, and wildlife (WAC 173-201A). The EPA administers NPDES permits for all projects on Federal and tribal lands. NPDES permits are not needed for hatchery and net-pen facilities that release less than 20,000 pounds of fish per year or feed fish less than 5,000 pounds of fish feed per year. Additionally, Native American tribes may adopt their own water quality standards for permits on tribal lands (i.e., tribal wastewater plans).

All hatchery facilities used by the Snohomish River basin salmon hatchery programs are operated in compliance with NPDES permits issued by the Washington Department of Ecology (state) or EPA (tribal), or do not require a NPDES permit, because annual fish production levels are below those of concern regarding effluent effects on fish (e.g., Eagle Creek Hatchery and Everett Bay Net-Pen). WDFW's Wallace River Hatchery is operated consistent with NPDES permit #WAG 13-3006 (WDFW 2013a). All hatchery effluent at Wallace River Hatchery would be passed through a pollution abatement pond to settle out any uneaten food and fish waste before being discharged into receiving waters (WDFW 2013a). Effluent discharge from the Tulalip Tribes' hatchery programs is in compliance with the NPDES permit requirements under the Clean Water Act, consistent with NPDES permits WAG-13-0012, WAG -13-0013, and WAG -13-0014 (Tulalip 2012). Water released as effluent, after use for fish rearing, would have no effect on ESA-listed fish because the tribal programs operate in small creeks where no listed Chinook salmon or steelhead exist. The effects of hatchery effluent discharge on downstream aquatic life, including listed Chinook salmon and steelhead, would be adequately minimized through compliance with federal and state permit requirements.

2.4.2.7 Fisheries

Hatchery salmon are produced for harvest in Snohomish River basin tribal and state fisheries, and in marine area fisheries targeting Chinook, coho, and fall chum salmon. As discussed earlier, these fisheries are subject to consultation on an annual or multi-year basis, depending on the duration of the Puget Sound fishery management plan submitted by the co-managers (NMFS 2017). The effects of fisheries on ESA-listed species to date are described in the Environmental Baseline (Section 2.3). There are no changes to those baseline effects as a result of the proposed action, and effects are expected to continue at similar or reduced levels relative to those described in the Environmental Baseline.

2.4.2.8 Effects of the Action on Critical Habitat

Negligible effect –
The effects of the proposed hatchery actions on designated critical habitat were analyzed through this consultation and NMFS determined that operation of the hatchery programs will have a negligible effect on PCEs for ESA-listed Chinook salmon and steelhead in the action area.

Existing hatchery facilities have not led to: altered channel morphology and stability; reduced and degraded floodplain connectivity; excessive sediment input; or the loss of habitat diversity. No new facilities or construction are proposed as part of the proposed actions considered in this opinion. With the exception of temporary, seasonally operated weirs on Wallace River and May Creek, all hatchery facilities are removed from Snohomish River basin waters where designated critical habitat for listed Chinook salmon and steelhead would be affected. Proposed surface water diversion for rearing juvenile salmon at Wallace River Hatchery, and return of that water to the Wallace River, would not affect the spatial distribution of adult or juvenile ESA protected Snohomish River basin Chinook salmon or steelhead. The programs would operate under stringent Washington State water right and NPDES permit criteria for diverting and discharging water, and would not have any discernible effect on, or result in any adverse modification to critical habitat. Permitted water withdrawal levels for fish rearing are a small fraction of average annual flows in freshwater areas where listed fish may be present, and water withdrawn for hatchery use is returned near the points of withdrawal. Hatchery diversion screens protect juvenile Chinook salmon and steelhead from entrainment and injury, and meet NMFS screen criteria, or are planned for retrofitting to meet those criteria. Compliance with NPDES permits issued for the Wallace River Hatchery and Tulalip Hatchery programs would help ensure that water quality in downstream areas where listed fish may be present is not degraded. Water used for fish production at Wallace River Hatchery would be adequately treated before it is returned to the river. No hatchery maintenance activities are proposed in the HGMPs that would adversely modify designated critical habitat.

Water intakes and screens used to supply water for Wallace River Hatchery are in compliance with NMFS (2005; 2006) screening criteria, but have not been updated based on the most recent criteria (NMFS 2011c). WDFW plans to upgrade fish screens at Wallace River Hatchery to ensure compliance with current NMFS fish passage and screening criteria by fall 2020. The water intake and screening are expected to be adequately protective of critical habitat for listed fish until the structure is renovated to be in compliance with current NMFS criteria.

Effluent discharge for the hatchery operations is not expected to degrade water quality. Consistent with effluent discharge permit requirements developed by EPA and the Washington Department of Ecology (WDOE) for upland fish hatcheries, water used for fish production at Wallace River Hatchery and the three Tulalip tribal hatchery programs would be adequately treated prior to discharge into downstream areas to ensure that federal and state water quality standards for receiving waters are met and that downstream aquatic life, including salmon and steelhead, are not adversely affected.

Wallace River Hatchery has a current NPDES permit (#WAG 13-3006) that requires monitoring, measurement, and monthly reporting to WDOE of water use, chemical use, and effluent discharge levels (WDFW 2013a). Tulalip Hatchery (#WAG 13-0012), Tulalip Creek Ponds (#WAG 13-0013), and

Battle Creek Pond (#WAG 13-0014) facilities have current NPDES permits which require monitoring, measurement, and monthly reporting on water use, chemical use, and effluent discharge levels (Tulalip 2012). Fish production at Eagle Creek Hatchery and the Everett Bay Net Pen facility is below annual levels for which a NPDES permit is required, and for which effects on water quality and fish are of concern. The following water quality parameters, selected by EPA and WDOE as important for determining hatchery-related water quality effects, are monitored under NPDES permits issued for the hatchery programs (WDFW 2013a):

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

Consistent with WDFW's NPDES permit for Wallace River Hatchery, all hatchery effluent would be passed through a pollution abatement pond to settle out any uneaten food and fish waste before being discharged into receiving waters (WDFW 2013a). WDFW reports that from 2008 through 2012, the Wallace River Hatchery program has been in compliance with all NPDES effluent discharge permit requirements, with three exceptions (WDFW 2013a). In 2008, the program recorded two instances where sampling indicated the Total Suspended Solids (TSS) limit in the hatchery effluent was exceeded. In 2009, the program recorded one instance where sampling indicated the TSS limit in the hatchery effluent was exceeded. Heavy rains and an undersized abatement pond contributed to the three TSS limit exceedances. A new abatement pond will be constructed by fall 2020 to reduce the risk of TSS limit exceedance in the future (WDFW 2013a). Effluent discharge from the Tulalip Tribes' hatchery programs is in compliance with the NPDES permit requirements under the Clean Water Act, consistent with NPDES permits WAG-13- 0012, WAG -13-0013, and WAG -13-0014 (Tulalip 2012). Water released as effluent after use for fish rearing would have no effect on listed fish because the tribal programs operate in small creeks that are tributaries to Tulalip Bay where no ESA-listed Chinook salmon or steelhead populations exist. The effects of hatchery effluent discharge on downstream aquatic life, including listed Chinook salmon and steelhead, resulting from implementation of the proposed hatchery programs would be adequately minimized through compliance with federal and state permit requirements.

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

2.5 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the Proposed Action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. For the purpose of this analysis, the action area is described in Section 1.4. Future Federal actions will be reviewed through separate section 7 consultation processes.

The federally approved Shared Strategy Recovery Plan for Puget Sound Chinook Salmon (SSPS 2005b), Volume II of the plan (SSPS 2005a), and the Snohomish River Basin Salmon Conservation Plan (SBSRF 2005) describe, in detail, the on-going and proposed state, tribal, and local government habitat, harvest, and hatchery management actions that are targeted to reduce known threats to Puget Sound Chinook salmon in the Snohomish River basin. A recovery plan for Puget Sound steelhead, including summer- and winter-run populations in the Snohomish River basin, is under development and scheduled for completion in 2018, but many of the actions implemented for Chinook salmon recovery also benefit steelhead. Future tribal, state, and local government actions will likely be in the form of legislation, administrative rules, policy initiatives, and land use and other types of permits. Government and private actions may include changes in land and water uses, including ownership and intensity, which could affect listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties.

Non-Federal actions are likely to continue affecting ESA-listed species. State, tribal, and local governments have developed plans and initiatives designed to protect and recover listed salmon and steelhead populations (SSPS 2005b; SBSRF 2005). Consistent with these plans, WDFW and the Puget Sound tribes will continue to implement hatchery management plans within the Puget Sound region similar to those evaluated in this opinion that can benefit or adversely affect listed Puget Sound Chinook salmon ESU and Puget Sound steelhead DPS populations in other watersheds. Puget Sound salmon and steelhead harvest management plans will be implemented to meet ESA-listed fish protection needs, consistent with recovery exploitation rate strategies evaluated and authorized by NMFS for listed fish effects (e.g., NMFS 2017). The cumulative effects of these and other non-Federal actions in the action area are difficult to analyze considering the geographic landscape of this opinion, the political variation in the action area, the uncertainties associated with government and private actions affecting salmon and steelhead habitat, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation, with the likelihood for future effects depending on the activity affecting the species, the non-Federal entity regulating the activity, and the condition of natural habitat, as affected by natural variance in environmental factors and climate change. However, we expect the activities identified in the baseline to continue at similar magnitudes and intensities as in the recent past. On-going State, tribal, and local government salmon restoration and recovery actions implemented through the Shared Strategy Plan (SSPS 2005b) and through other associated plans and initiatives (e.g., SSPS 2005a) are expected to continue and to help lessen the effects of non-Federal land and water use activities on the status of listed fish species. The temporal pace of such decreases would be similar to the pace observed in recent years. With these improvements, however, based on the trends discussed above, there is also the potential for adverse cumulative effects associated with some non-Federal actions to increase (Judge 2011). State, tribal, and local governments have developed resource use plans and initiatives to benefit listed fish and offset any growing adverse effects that are proposed to be applied and sustained in a comprehensive way (e.g., SBSRF 2005). But the actions must be reasonably certain to occur to be considered cumulative effects, and, for the reasons outlined above, they are too speculative to meet that test.

Numerous non-Federal habitat protection and restoration projects and activities, funded with Federal and state dollars, are benefitting fish included in the Puget Sound Chinook salmon ESU and Puget Sound steelhead DPS, including populations of the species in the Snohomish River basin. Following the fish restoration strategies described in the Shared Strategy Plan (SSPS 2005b), in the NMFS Supplement to the recovery plan (NMFS 2006), and in the Snohomish River watershed volume of the Shared Strategy

Plan (SSPS 2005a), non-Federal projects and activities have been implemented to address watershed-specific limiting factors to salmon viability. Habitat protection and restoration actions implemented thus far have largely focused on preservation of existing habitat and habitat-forming processes; protection of nearshore environments, including estuaries, marine shorelines, and Puget Sound; instream flow protection and enhancement; and reduction of forest practice and farming impacts to salmon habitat. Specific actions to recover salmon and steelhead in Puget Sound watersheds, including the Snohomish River basin (recent examples included in Section 2.3.4), have included: implementation of land use regulations to protect existing habitat and habitat-forming processes through updating and adopting Federal, state, and local land use protection programs, as well as more effectively combining regulatory, voluntary, and incentive-based protection programs; implementation of nearshore and shoreline habitat protection measures such as purchase and protection of estuary areas important for salmon productivity; protection and restoration of habitat functions in lower river areas, including deltas, side-channels, and floodplains important as rearing and migratory habitat; implementation of protective instream flow programs to reserve sufficient water for salmon production; and implementation of protective actions on agricultural lands. Because the projects often involve multiple parties using Federal, state and utility funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects.

The salmon hatchery programs implemented under the proposed action would affect two of the twenty-two Chinook salmon populations composing the Puget Sound Chinook salmon ESU, and five of the thirty-two steelhead populations making up the Puget Sound steelhead DPS. Other co-manager salmon and steelhead hatchery programs operating in other Puget Sound watersheds will affect other ESA-listed Chinook salmon and steelhead populations in the ESU and DPS, respectively. For Chinook salmon, the effects of these hatchery programs on ESU recovery depend on the recovery standing of the populations affected within each of the five biogeographical regions composing the ESU (NMFS 2010a). Consistent with criteria specified in NMFS's supplement to the Shared Strategy Recovery Plan (NMFS 2007), at least two Chinook salmon populations within each biogeographical region must be recovered to a viable status for the ESU to be considered recovered and subject to delisting. The Whidbey Basin biogeographical region includes six Chinook salmon populations in the Skagit River watershed, in addition to the Skykomish and Snoqualmie Chinook salmon populations affected by the proposed action. The six Skagit River populations are considered "Tier 1" populations for ESU recovery, and are the primary populations determining the viability status of the Whidbey Basin region and the ESU. The Skykomish and Snoqualmie Chinook salmon populations are Tier 2 and Tier 3 populations, respectively, and are on a lower trajectory for recovery than the Skagit River populations (NMFS 2010a). Although NMFS has yet to complete ESA consultation on the effects on Skagit River basin hatchery programs on listed Chinook salmon and steelhead, production of hatchery salmon in the watershed is unsubstantial relative to natural fish production in the watershed, and the risk of adverse effects on listed fish is likely low. For these reasons, considering the effects of the other hatchery programs in the Whidbey Basin biogeographical region including the Skagit River, the additive effects of the proposed action are unlikely to change prospects for achieving recovery within the Whidbey Basin region or the Puget Sound Chinook salmon ESU as a whole. A recovery plan has yet to be completed for the Puget Sound steelhead DPS, and the recovery standing of each DIP within the major population groupings identified in the DPS has yet to be determined. The Skagit River watershed supports six of the 32 steelhead populations in the DPS, hatchery salmon production is relatively low and there is no hatchery steelhead production, and the watershed retains the best habitat conditions for steelhead productivity in the region. Similar to Chinook salmon, it is likely that the additive effects of the proposed action would not change prospects for achieving steelhead recovery within the North Cascade region or the DPS as a whole. Our perspectives regarding the effects of the salmon hatchery program actions in the Snohomish River basin on the Puget Sound Chinook salmon ESU and Puget Sound steelhead DPS are therefore unchanged when considering the additive effects of hatchery salmon and steelhead production across the Puget Sound region.

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 (Section 2.3) and to cumulative effects (Section 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.

In assessing the overall risk of the Proposed Action on each species, NMFS considers the risks of each factor discussed in Section 2.4.2 above, in combination, considering their potential additive effects with each other and with other actions in the area (environmental baseline and cumulative effects). This combination serves to translate the threats posed by each factor of the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciable reduce the likelihood of survival and recovery of the listed species.

2.6.1 Puget Sound Chinook Salmon

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

Based on a review of the proposed hatchery actions (Section 1.3), the status of affected Snohomish River basin Chinook salmon populations (Section 2.2.1), and consideration of environmental baseline conditions (Section 2.3) and cumulative effects (Section 2.5), the assigned effects of the proposed salmon hatchery actions on Puget Sound Chinook salmon range from negative to beneficial (Section 2.4.2; Table 12).

The viability status of the two Snohomish River basin Chinook salmon populations is poor. Spawner abundance is currently depressed but stable at levels above the critical thresholds, and remaining population diversity, spatial structure, and productivity are below desired levels required for the populations to recover to a self-sustaining condition (Section 2.2.1). Both populations in the basin currently do not assume primary roles for recovery of the Puget Sound Chinook Salmon ESU (Section 2.2.1.1). Due to the poor to fair condition of habitat, the Snohomish River basin Chinook salmon populations remain in the "preservation" or "recolonization" phases of restoration (Rawson and Crewson 2017), and best management practices at hatchery programs are necessary to maintain the recoverability of the two native Chinook salmon populations. Of the effects categories evaluated, four hatchery–related factors - Chinook salmon hatchery program effects on genetic diversity; spawning ground competition and redd superimposition effects from Wallace River Hatchery-origin coho salmon; Wallace River Hatchery yearling Chinook and coho salmon and Eagle Creek Hatchery coho salmon predation effects; and Wallace River Hatchery water intake screening effects on Chinook salmon survival and migration - were assigned as potentially posing negative effects on listed Chinook salmon in the Snohomish River basin (see Section 2.4.2). The remaining hatchery-related factors identified in Table 12 would have impacts that were not applicable, or negligible in magnitude (Section 2.4.2) and would not affect the viability status of the listed Snohomish River basin Chinook salmon populations to any measurable degree.

2.6.1.1 Genetic Effects

Although potentially posing negative effects on listed Chinook salmon, analyses of genetic diversity and fitness loss risks presented above for the proposed hatchery programs for the species indicate that risk levels will be low (see Section 2.4.2.2). In implementing the Wallace River Hatchery and Tulalip Hatchery Chinook salmon programs, the co-managers will apply BMPs for genetic risk reduction as part of the proposed action. Representing best available science, NMFS expects that these BMPs, including incorporation of natural-origin fish as broodstock, should limit the effects that the proposed Chinook salmon hatchery programs would have on the genetic diversity and fitness of the Skykomish and Snoqualmie Chinook salmon natural populations. The co-managers would monitor and report annual run timing, location, age and sex composition, and origin of escaping Chinook salmon to warn of any changes in Chinook salmon population traits that may be associated with hatchery program implementation. Tissues would be collected for genetic analysis from adult fish recovered in natural spawning areas, adult fish collected for use as broodstock at Wallace River Hatchery, and juvenile fish progeny of naturally spawning Chinook salmon (WDFW 2013a). These genetic data would be used to monitor levels of gene flow between hatchery fish and the two Chinook salmon natural populations, the genetic diversity status of the Skykomish and Snoqualmie natural populations, and any divergence between hatchery fish and the natural Skykomish Chinook salmon population.

2.6.1.2 Spawning Ground Interactions

Hatchery-origin adult salmon produced through the Wallace River Hatchery Chinook and coho salmon programs and released into the Wallace River that escape to spawn naturally have the potential to adversely affect Chinook salmon populations in the Snohomish River basin through competition for spawning sites and redd superimposition. The Snohomish River basin is under-seeded with naturally spawning Chinook salmon, and considering current hatchery-origin fish contribution levels to naturally spawning, competition for spawning sites with adult hatchery-origin Chinook salmon and redd superimposition by hatchery Chinook salmon, are not concerns. Skykomish River stock coho salmon adults originating from the hatchery programs that escape to natural spawning areas are unlikely to compete with Chinook salmon for spawning sites or superimpose Chinook salmon redds because there is little temporal or spatial overlap between the two species. Coho salmon adults straying from their Wallace River Hatchery release site have a later spawn-timing and are likely to spawn in areas outside of the primary summer Chinook salmon spawning areas.

Chinook, coho, and fall chum salmon produced by the Tulalip Tribes' hatchery programs are released into the Tulalip Creek watershed; an area outside of the Snohomish River freshwater areas supporting

Chinook salmon. Mark recovery data indicate that tribal program-origin salmon produced in the Tulalip Creek watershed have a high return fidelity as adults to Tulalip Bay, where high harvest rates in tribal net fisheries remove most returning adults. Straying by salmon from the tribal hatchery programs into adjacent Snohomish River basin freshwater areas occurs at low levels that would make substantial spawning ground competition and redd superimposition effects on Chinook salmon populations unlikely. Because of a low total adult return level and low expected stray rate of the total return, adult coho salmon originating from Everett Bay Net-Pen releases would also not escape to Snohomish River basin tributaries in substantial numbers, and below levels of concern regarding these hazards.

For these reasons, this risk factor is unlikely to pose any risks to the viability of the Skykomish and Snoqualmie Chinook salmon populations, or impede their recovery to a viable status, and on-going monitoring would make management responses possible if conditions warrant.

2.6.1.3 Predation

The only threat of hatchery fish predation on fish from natural populations in the Snohomish River basin is associated with releases from the yearling Chinook and coho salmon hatchery programs. Chinook salmon yearlings released in April into the Wallace River would be of large enough size to prey on juvenile Chinook salmon less than approximately 61 mm fork length present in the Wallace and Skykomish rivers when the hatchery fish would be released. Although of similarly large size at the time of their release, hatchery-origin coho salmon yearlings would be released from Eagle Creek and Wallace River Hatchery in April and May, respectively, when the majority of juvenile Chinook salmon from the natural populations would generally be too large (average size is 53 mm fl) to be vulnerable to predation (see Table 17). Chinook salmon fry and parr below this average fish size would be at risk of predation by the hatchery yearling coho salmon released from the two hatchery sites. However, the risk of predation would be attenuated by the known rapid downstream seaward emigration behavior of newly released hatchery-origin smolts (Section 2.4.2.3).

Subyearling Chinook salmon released through the proposed Wallace River Hatchery program would not pose risks of predation because they are too small and because of diet preferences. The proposed hatchery programs for yearling Chinook and coho salmon would apply BMPs to reduce the potential for predation. Salmon produced through the Tulalip Tribes' salmon hatchery programs would be released as smolts or fry into Tulalip Bay, or at RM 0.1 on Battle Creek, which lacks ESA-listed natural-origin salmonid populations. Coho salmon yearlings from the Everett Bay Net-pen program would be released directly into seawater. There would therefore be no predation risks to listed fish in freshwater areas within the action area associated with the Tulalip Tribal Chinook, coho, and fall chum salmon hatchery programs, and Everett Bay Net-Pen coho salmon releases.

Juvenile out-migrant monitoring would continue in the lower Skykomish and Snoqualmie river watersheds to determine annual salmonid size and emigration timing by species and origin, and to identify spatial and temporal overlap between hatchery-origin Chinook and coho salmon yearlings and juvenile Chinook salmon from both natural populations. The release programs for hatchery yearlings could be revised if juvenile out-migrant monitoring in the Snohomish River basin indicates that release timings result in substantial overlap with, and associated predation risks. For these reasons, the magnitude of effects is likely low, and hatchery yearling predation is unlikely to pose substantial risks to the viability of the Skykomish and Snoqualmie Chinook salmon populations, or impede their recovery to a viable status, and on-going monitoring would make management response possible if conditions warrant. NMFS will monitor emerging science and information related to interactions between hatchery fish and fish from natural populations and will consider whether re-initiation of consultation is required in the event that new information regarding predation by hatchery fish reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.6.1.4 Water Intake Effects

Hatchery operation and maintenance activities pose risks to ESA-listed Chinook salmon abundance. The water intake and associated screens used for the Wallace River Hatchery programs may not be adequately protective of juvenile fish from entrainment and injury (Section 2.4.2.6). Although the water intake screens on the Wallace River and May Creek are in compliance with state and federal guidelines (NMFS 1995; 1996), they do not meet the newest criteria (NMFS 2011c). WDFW is in the process of updating fish passage protections at the location of the Wallace River and May Creek water intake structures, with plans to complete work by fall 2020.

When renovated, the Wallace River Hatchery structures will not likely pose substantial fish passage risks to migrating juvenile and adult salmon. The current water intakes on the Wallace River and May Creek meet NMFS previous screening criteria (NMFS 2008a), and NMFS (2011c) states that such screening is adequately protective of listed Chinook salmon from impingement and entrainment effects until the structures are renovated, when at that time, they must meet current NMFS screening criteria (NMFS 2011c). WDFW will ensure that screening on the new water intake is in compliance with the latest NMFS criteria when construction is completed. This upgrade in the hatchery facility would reduce the risk that listed salmon and steelhead would be incidentally entrained, injured, or killed through operation of Wallace River Hatchery.

Surface water withdrawals have the potential to impact Chinook salmon migration, spawning, and rearing. However, a review of past operations at the hatcheries reveals that water withdrawal amounts for fish rearing during the summer-time low flow periods, when any effects would be most pronounced, is much less than the permitted maximum hatchery withdrawal levels. Fish biomass at the hatchery rearing locations, and required water withdrawal amounts, would reach the maximum permitted levels only in the late winter and spring months, just prior to fish release dates, when the fish are at their largest size, and flows are at their highest levels. Hatchery water needs are at their lowest level during the summer and fall months, when juvenile fish biomass, and associated water supply needs, are at annual minimums. For these reasons, the magnitude of effects on natural populations of Chinook salmon is expected to be low; the proposed actions are unlikely to pose substantial risks to the viability of the Skykomish Chinook population, or impede its improvement to a viable status. On-going monitoring would make management responses possible if conditions warrant.

2.6.1.5 Summary of Effects on Chinook Salmon

The Federally approved Recovery Plan for Puget Sound Chinook salmon (Ruckelshaus et al. 2005; SSPS 2005), the Washington Conservation Commission's WRIA 7 Limiting Factors Analysis (Haring 2002), and the Snohomish River Basin Salmon Conservation Plan (SBSRF 2005) identified primary limiting factors and threats to Chinook salmon populations in the Snohomish River basin. These limiting factors and threats, summarized in SSPS (2005) are: loss of estuarine and marine habitats due to residential and industrial development and urbanization; poor quality riparian forests and decreased forest cover as a result of clearing land for timber, farming, road building, and residential and urban development; lack of habitat complexity that provides pools and back-eddies, providing food and refuge for salmon; loss of natural hydrologic function, resulting in scouring flood flows; loss of floodplain function, including loss of wetlands and off-channel habitats; disruption of natural sediment processes; and loss of access to habitat from poorly designed culverts and other human-made structures. The Proposed Action considered in this opinion would not affect any of these factors in a measurable way.

This analysis has considered limiting factors identified for the ESA-listed Puget Sound Chinook salmon ESU, and effects of the proposed action on the ESU, combined with other past and ongoing activities inside the action area, including implementation of conservative harvest management actions (Section 2.3.1), the effects of past hatchery operations (Section 2.3.3), and habitat protection and restoration projects implemented to benefit ESU viability (Section 2.3.4). As discussed in the Environmental Baseline, habitat conditions in the action area have been heavily impacted by human activities, resulting in conditions that in many locations are not favorable to Chinook salmon rearing and migration. In the Cumulative Effects (Section 2.5), there is a description of the progress toward turning around declining habitat conditions, particularly in the Snohomish River basin. The expectation is that as habitat preservation and restoration initiatives continue and, given time for restorative natural processes to mature (e.g., side-channel and riparian development and the resulting recruitment of large wood to streams), conditions for fish will naturally improve. As discussed in Section 2.5, the Skykomish and Snoqualmie Chinook salmon populations affected by the proposed action are in the same biogeographical region as six Skagit River basin populations that are considered the primary populations for ESU recovery. Because hatchery production levels are relatively low in the Skagit River watershed, and hatchery Chinook salmon straying from other watersheds (including fish produced under the proposed action) is unsubstantial relative to total natural Chinook salmon escapement in the Skagit River (total annual basin-wide pHOS is <5% [SSC and WDFW 2015]), NMFS expects that hatchery-related effects will not substantially hinder recovery of the six Chinook salmon populations, or contribute cumulatively to the effects of the proposed action on ESU recovery. In the meantime, the proposed action would pose low levels of risk resulting from natural spawning by hatchery Chinook salmon, and predation during short durations when yearling hatchery fish are leaving freshwater and estuarine areas for the ocean. Renovation actions at Wallace River Hatchery - the only hatchery facility impacting ESA-listed fish through facility effects - are expected to be completed shortly after issuance of this opinion. In summary, the effects of these hatchery programs have been minimized to the point where, added to the Baseline and Cumulative Effects, they will have no more than minor effects on ESA-listed populations in the action area.

As discussed above, certain aspects of the proposed action are expected to have some negative effects on ESA-listed Chinook salmon, however, any effects on will be minor and not limit, or delay achievement of, population viability. BMPs implemented to reduce hatchery-related ecological and demographic effects on Chinook salmon, in combination with very robust RM&E actions, are expected to eliminate any possibility that the proposed action will appreciably reduce the likelihood of survival and recovery of the Puget Sound Chinook Salmon ESU in the wild.

2.6.2 Puget Sound Steelhead

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

Based on a review of the proposed hatchery actions (Section 1.3), the status of affected Snohomish River basin steelhead populations (Section 2.2.2), and consideration of environmental baseline conditions (Section 2.3) and cumulative effects (Section 2.5), the assigned effects of the proposed salmon hatchery actions on Puget Sound steelhead range from not applicable to beneficial (Section 2.4.2; Table 12). The viability status of the Snohomish River basin steelhead populations is poor. Spawner abundance is currently depressed, and remaining population diversity, spatial structure, and productivity are also below desired levels required for the population to recover to a self-sustaining condition (Section 2.2.2.1). Of the effects categories evaluated, one hatchery–related factor - Wallace River Hatchery water intake screening effects on steelhead survival and migration - was assigned a potential to pose negative effects on listed steelhead in the Snohomish River basin (see Section 2.4.2). Since the intake screens are scheduled for replacement and updating this year, effects of this factor are considered inconsequential. The remaining hatchery-related factors identified in Table 12 would have impacts that were not applicable, or negligible in magnitude (Section 2.4.2) and would not affect the viability status of the listed Snohomish River basin steelhead populations.

2.6.2.1 Water Intake Effects

Hatchery operation and maintenance activities would impact ESA-listed steelhead abundance, but at very low levels. The water intake for the Wallace River hatchery programs is screened to protect fish and only needs to be updated to meet the most recent criteria (Section 2.4.2.6). WDFW is in the process of updating the screens, with plans to complete work by fall 2020.

As noted in Section 2.6.1.4, when renovated, the Wallace River Hatchery structures will not likely pose substantial fish passage risks to migrating juvenile and adult steelhead. The current water intakes on the Wallace River and May Creek meet NMFS previous screening criteria (NMFS 2008a), and NMFS (2011c) states that such screening is adequately protective of listed steelhead from impingement and entrainment effects until the structures are renovated, when at that time, they must meet current NMFS screening criteria (NMFS 2011c). WDFW will ensure that screening on the new water intake is in compliance with the latest NMFS criteria when construction is completed (WDFW 2013a). This upgrade in the hatchery facility would reduce the risk that listed salmon and steelhead would be incidentally entrained, injured, or killed through operation of Wallace River Hatchery.

Surface water withdrawals have the potential to impact steelhead migration, spawning, and rearing. However, a review of past operations at the hatcheries reveals that water withdrawal amounts for fish rearing during the summer-time low flow periods, when any effects would be most pronounced, is much less than the permitted maximum hatchery withdrawal levels. Fish biomass at the hatchery rearing locations, and required water withdrawal amounts, would reach the maximum permitted levels only in the late winter and spring months, just prior to fish release dates, when the fish are at their largest size, and flows are at their highest levels. Hatchery water needs are at their lowest level during the summer and fall months, when juvenile fish biomass, and associated water supply needs, are at annual minimums. For these reasons, the magnitude of effects on natural populations of steelhead is expected to be low; the proposed actions are unlikely to pose substantial risks to the viability of the three Snohomish River basin steelhead DIPs, or impede their improvement to a viable status. On-going monitoring would make management responses possible if conditions warrant.

2.6.2.2 Summary of Effects on Steelhead

Criteria and guidance for steelhead conservation have been developed and represent best available science (Myers et al. 2015; Hard et al. 2015) for use in consultations until a federally approved recovery plan for Puget Sound steelhead is completed. That plan is currently under assembly, and is projected to be completed in 2018. In most recent ESA status review update for the Puget Sound steelhead DPS, NMFS identified primary limiting factors and threats to distinct independent populations composing the DPS, including the steelhead populations in the Snohomish River watershed (NWFSC 2015). Threats include the continued destruction and modification of steelhead habitat (the principal factor limiting DPS viability); widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years; threats to diversity from non-local hatchery steelhead stocks (EWS and ESS); declining diversity in the DPS, including the uncertain, but likely poor status of summer-run fish in the DPS; reduction in spatial structure for steelhead in the DPS associated with large numbers of barriers, such as impassable culverts, together with declines in natural abundance, that greatly reduce opportunities for adfluvial movement and migration between steelhead groups within watersheds; reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris; increased flood frequency and peak flows during storms, and reduced groundwater-driven summer flows in the lower reaches of many rivers and their tributaries where urban development has occurred, that have resulted in gravel scour, bank erosion, and sediment deposition; and dikes, hardening of banks with riprap, and channelization, which have reduced river complexity and sinuosity, and have increased the likelihood of gravel scour and dislocation of rearing juveniles (Section 2.2.1.2). The Proposed Action considered in this opinion would not affect any of these factors in a measurable way.

This analysis has considered limiting factors, as described in the recent status review update, and the effects of the proposed action on the Puget Sound Steelhead DPS, combined with other past and ongoing activities inside the action area, including implementation of conservative harvest management actions (Section 2.3.2); the effects of past hatchery operations (Section 2.3.3); implementation of new and improved hatchery practices (NMFS 2015); and habitat protection and restoration projects implemented to benefit DPS viability (Section 2.3.4). As discussed in the Environmental Baseline, and Cumulative Effects, meaningful actions to restore and reconnect habitat are underway with prospects for improved habitat conditions in the future. At this time and for the near future, habitat conditions in the action area are not favorable to steelhead rearing and migration. However, the proposed action has only minimal impacts on a few aspects of the Baseline – specifically the minor and short-term (through fall 2020 only) effects of the operation of the screened Wallace River Hatchery water intake. The effects of the water intake structure will be reduced further upon installation of screens meeting current NMFS guidance. The impacts of EWS hatchery program in the action have been significantly reduced compared to past impacts, and are currently minimal. In summary, the effects of the six hatchery salmon programs have been minimized to the point where, added to the Baseline and Cumulative Effects, they will have no more than minor effects on the ESA-listed steelhead populations in the action area.

Taken together, the proposed actions are expected to have unsubstantial negative effects on the Puget Sound steelhead DPS. As discussed above, some low, minor negative effects to steelhead populations in the action area are expected, however, none are expected to rise to the level at which they would have more than very minor effects on population viability or more than negligible effects on DPS survival and recovery. Measures implemented to reduce hatchery-related demographic effects on ESA-listed steelhead are based on best management practices designed to further lessen risks to affected natural steelhead populations. This analysis leads to a determination that the subject salmon hatchery programs will have negative but very limited impacts on ESA-listed steelhead and that they will not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the Puget Sound Steelhead DPS.

2.6.3 Critical Habitat

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

The water intake structures used by Wallace River Hatchery on the mainstem Wallace River and in May Creek as currently designed do not pose substantial risks to critical habitat associated with upstream and downstream anadromous fish access. Screening at both sites is in compliance with NMFS (2005) and NMFS (2006) screening criteria, and water intakes used are in the process of being replaced or renovated so that they will be in compliance with the most up to date NMFS fish passage and screening criteria (NMFS 2011c). For the interim period, the water intake structures at Wallace River Hatchery are expected to pose only low and unsubstantial risks to Chinook salmon and steelhead critical habitat in the action area (Sections 2.4.2.6 and 2.4.2.8). Screening at Wallace River Hatchery would be upgraded by fall 2020 to reduce risks to rearing and migrating Chinook salmon and steelhead. Water intake screens, when replaced, will pose a negligible effect to designated critical habitat in the action area (see Section 2.4.2.8). Otherwise, the proposed action will not affect critical habitat for Chinook salmon and steelhead. Existing hatchery facilities have not altered channel morphology and stability, floodplain connectivity, sediment input, or the loss of habitat diversity, and no new facilities or changes to existing facilities are proposed.

Water use and management under the Proposed Actions include requirements to comply with limits and strict criteria for withdrawing and discharging water used for fish rearing. This evaluation concludes that these actions will not have any discernible effect or result in any adverse modification to critical habitat. For hatchery water withdrawals, the worst-case scenario of maximum permitted levels for fish rearing was considered, but it was determined to be unrealistic because water withdrawal amounts for hatchery fish rearing during the summertime low flow periods, when any effects would be most pronounced, will be much less than the permitted maximum levels. Fish biomass at the hatchery rearing locations, and required water withdrawal amounts, would reach maximum permitted levels only in the late winter and spring months just prior to fish release dates, when the fish are at their largest size, and flows in the

Snohomish River basin approach their annual maximums. Hatchery water needs are at their lowest level during the summer and fall months, when juvenile fish biomass, and associated water supply needs, are at annual minimums. Dewatering of critical habitat for salmon and steelhead in the action area that may lead to substantial effects is therefore highly unlikely.

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

2.6.4 Climate Change

Chinook salmon and steelhead populations in the Snohomish River basin will be adversely affected by continued climate change (see Section 2.2.3). A decrease in winter snow pack resulting from predicted rapid changes over a geological scale in climate conditions in the Cascade Mountains would be expected to reduce spring and summer flows, impairing water quantity and water quality in primary fish rearing habitat located in the mainstem Skykomish, Snoqualmie, and Snohomish Rivers. Predicted increases in rain-on-snow events would increase the frequency and intensity of floods in mainstem river areas, leading to scouring flows that would threaten the survival and productivity of natural-origin listed fish species. The proposed Snohomish River basin programs for Chinook salmon are expected to help attenuate these impacts to the Skykomish Chinook population 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.

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 of the Proposed Actions 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 continued existence of the Puget Sound Chinook Salmon ESU and the Puget Sound steelhead DPS, or to destroy or adversely modify designated critical habitat for the ESU and DPS.

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.[17] 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 six factors applicable to the proposed hatchery salmon actions. Four factors analyzed are likely to result in some level of take (from individual fish to larger numbers of fish) of ESA-listed Puget Sound Chinook salmon: Chinook salmon hatchery program effects through broodstock collection; program effects on genetic diversity; Wallace River Hatchery yearling Chinook and coho salmon predation effects; and Wallace River Hatchery water intake screening effects on Chinook salmon survival and migration. One factor is likely to result in take of listed Puget Sound steelhead: Wallace River Hatchery facility water intake screening effects on steelhead survival and migration.

Take through Broodstock Collection

Annual collection of broodstock to sustain the Wallace River Hatchery program will lead to the removal of listed natural Skykomish Chinook salmon from the Sunset Falls Fishway trap, from traps located in the Wallace River, and through collections of broodstock downstream of the Wallace River Hatchery rack. Up to 400 natural-origin adult Chinook salmon may be taken through their removal for holding and spawning at the hatchery each year. In addition, up to 1,912 natural-origin Skykomish Chinook salmon may be captured, handled and released incidentally during annual broodstock collection actions at Wallace River Hatchery, in the Wallace River, and at Sunset Falls Fishway (Table 1a in WDFW 2013a). Of this total, capture, handling and release effects for 1,000 natural-origin Chinook salmon encountered during operation of the Sunset Falls Fishway program were previously authorized through a separate ESA consultation, with an expected unintentional annual mortality of 50 listed natural-origin adults (NMFS 2009). For the 912 fish encountered at Wallace River Hatchery and downstream areas that are not retained as broodstock, incidental take effects may include migration delay, injury, and unintentional mortality.

NMFS expects that the total annual number of natural-origin Skykomish Chinook salmon captured, handled and held for spawning for the Wallace River Hatchery program will not exceed 400 adult fish, of which 100 fish may die before spawning. Further, NMFS expects that the number of Skykomish Chinook salmon incidentally captured, handled, and released during annual Wallace River Hatchery, and in-Wallace River, Chinook and coho salmon broodstock collection activities (excluding Sunset Falls

[17] 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 U.S. Fish and Wildlife interpretation of the term.

Fishway) will not exceed 912 fish. Of the 912 fish captured, handled, and released, 307 fish may be taken each year through unintentional mortality (Table 1a in WDFW 2013a - 457 fish less 50 fish that die as a result of the Sunset Falls Fishway operation (NMFS 2009) and less 100 fish that expire during holding for spawning).

Take by Genetic Effects

To address the challenges posed by substantial and ongoing habitat degradation in Puget Sound to salmon recovery efforts, NMFS is currently conducting a review of the empirical science, theory, guidelines, and tools relevant to understanding and assessing genetic risks posed by hatchery programs in cooperation with state, tribal, and federal geneticists. The terms and conditions described below may be revised in the future based on the outcome of this review.

As described in Section 2.4.2.2, implementation of the Wallace River Hatchery (WDFW 2013a) and Tulalip Hatchery (Tulalip 2012) Chinook salmon programs have the potential to result in some degree of genetic impact to the Skykomish and Snoqualmie Chinook salmon populations. It is not possible to measure genetic effects on Snohomish River basin Chinook salmon solely assignable to hatchery actions in a manner that would allow for the precise quantification of genetic take, necessitating use of surrogate take variables. Ideally we would select PNI as a surrogate take variable for effects on the Skykomish Chinook population, because that population is genetically linked to the integrated Wallace River Hatchery program. However, because of recent declines in adult return abundances (Section 2.2.1.1) and current predictions for poor returns in the next few years (Werner et al. 2017), aggressiveness in the collection of NORs for broodstock must be balanced against demographic concerns. Therefore, we have chosen pNOB and pHOS as duel metrics rather than a single PNI metric as surrogate take variables for the two Snohomish River basin hatchery programs. As reviewed in Sections 2.4.2.1 and 2.4.2.2, both metrics bear on the level of influence of the hatchery Chinook salmon programs on natural Chinook salmon population genetic diversity. The two metrics therefore have a rational relationship to assessing the level of take caused by genetic effects. Both pHOS and pNOB can be reliably measured and monitored through a combination of carcass surveys, CWT analysis, otolith analysis, and genetic monitoring.

The pNOB metric is based on a sliding scale (Table 13), to allow moderation of the number of NORs incorporated as broodstock considering the best available estimate of annual abundance relative to the low abundance threshold (LAT)[18] of 1,745 natural origin fish for the Skykomish Chinook salmon population.

The other surrogate take metric for the Tulalip and Wallace River Chinook salmon programs is a 4 –year running average pHOS level in the Skykomish River basin of no more than 35% attributable to these programs, combined, based on $pHOS_D$. The metric for this take surrogate will be a 4-year arithmetic running mean computed over those years where forecasted or in-season assessments of NOS abundance are estimated to be above the LAT.

[18] The decision of whether NOS abundances are above or below the LATs must be made by the co-managers utilizing the best available pre-season or in-season assessments of NOR abundances available at the time of broodstock collections completed July-September annually. However, the intent in any given year is to use all of the NORs encountered at the Wallace River Hatchery rack, up to the 400 fish ceiling, subject to environmental conditions and available escapement.

As previously described in Section 2.6, and below in Section 2.8.4, not meeting these metrics would trigger review where all of the relevant causative factors affecting the surrogate take metric(s) would be evaluated together. NMFS would weigh the effects of all concurrent harvest and hatchery management actions with all relevant habitat and climate change effects that bear on the surrogate metric(s) before recommending any corrective actions pertaining to the Proposed Action.

Take by Predation Effects

NMFS has determined that juvenile hatchery fish from the Wallace River Hatchery yearling Chinook and coho salmon programs are likely to prey on juvenile Chinook salmon from the Skykomish and Snoqualmie natural populations. It is not possible to quantify the take associated with predation in the action area, because it is not possible to meaningfully measure the number of interactions between hatchery-origin yearling salmon and juvenile Chinook salmon from several populations.

Therefore, NMFS will rely on a surrogate take indicator showing the proportion of the estimated total annual Wallace River Hatchery and Eagle Creek Hatchery-origin yearling Chinook and coho salmon in the lower Skykomish River that have emigrated seaward, past the juvenile outmigrant trapping site on the lower Skykomish River watershed for the period after the hatchery fish are released.

As a surrogate for predation take, NMFS expects that annual juvenile outmigrant trap-based analysis to show that 90% of the Wallace River Hatchery-origin yearling Chinook and coho salmon and Eagle Creek coho salmon smolt populations released each year will have exited freshwater areas downstream of the hatchery release sites on or after the 21st day after the last release of the yearling smolts. The estimated number of yearling smolts passing the trapping sites can be reliably calculated by statistical week, commencing the fourth week post-hatchery release and continuing until no hatchery-origin yearling Chinook and coho salmon are captured, as identified through either expanded estimates or CPUE.

This standard has a rational connection to the amount of take expected from ecological effects, since the co-occurrence of hatchery-origin and natural-origin fish is a necessary precondition to predation, and the assumption that the greater the proportion of yearling Chinook and coho salmon hatchery smolts of total annual releases remaining in freshwater post-release, the greater likelihood that predation will occur. The number of yearling Chinook and coho salmon smolts in the downstream salmon and steelhead rearing and migration areas will be monitored by standing co-manager juvenile out-migrant screw trap monitoring activities.

Take by Facility Effects

The existing Wallace River Hatchery water intake structure takes ESA-listed Chinook salmon and/or listed steelhead through migration delay or impingement of fish on screens. Because take by water intake structures occurs in the water and effects of delay or impingement may not be reflected until the fish have left the area of the structure, it is not possible to quantify the level of take associated with operation of the current water intake structures. Therefore, NMFS will rely on a surrogate take indicator in the form of the amount of habitat affected by the intake structure.

Currently, the intake structure affects a very small proportion of the 2,718 miles (4,374 km) of river and stream habitat available to salmon and steelhead in the Snohomish River basin (Section 2.3). The

Wallace River Hatchery water intake presents risks of entrainment for juvenile fish in no more than a total of 4 square meters of migration and rearing area adjacent to the intake, where intake water velocities may be high enough to cause fish to be drawn from the Wallace River into the intake screens. Therefore, the surrogate metric for take is the extent of habitat impacted by the intake, expected to be no more than four square meters.

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

2.8.2 Effect of the Take

In Section 2.7, NMFS determined that the level of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to Puget Sound Chinook salmon and Puget Sound steelhead or in the destruction or adverse modification of designated critical habitat.

2.8.3 Reasonable and Prudent Measures

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

1. Ensure that hatchery-related effects on ESA-listed Snohomish River basin Chinook salmon population abundance, genetic diversity, and fitness associated with implementation of the Wallace River Hatchery and Tulalip Hatchery Chinook salmon programs are inconsequential.
2. Ensure that predation effects associated with implementation of Wallace River Hatchery yearling Chinook salmon and coho salmon, and Eagle Creek Hatchery coho salmon programs are not a substantial threat to the Snohomish River basin Chinook salmon populations.
3. Ensure that screening for the Wallace River Hatchery is renovated so that all screening at the facility complies with NMFS (2011c) "Anadromous Salmonid Passage Facility Design" criteria by fall 2020.
4. Ensure that any natural origin steelhead, and bull trout, encountered during salmon broodstock collection operations are released back into the natural environment unharmed, and that annual encounter levels with the species are reported.
5. Implement the hatchery programs as described in the six salmon HGMPs and monitor their operation.
6. Document 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 annual reports.

2.8.4 Terms and Conditions

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

1a. Conduct annual surveys to determine the migration timing, abundance, distribution, and origin (hatchery and natural-origin) of Chinook salmon spawning naturally and escaping to hatchery releases sites in the Snohomish, Skykomish, and Snoqualmie river watersheds. The co-managers shall submit any revisions of protocols described in the proposed HGMPs for annual spawning ground surveys and biological sampling for NMFS concurrence on or before June 1 of each year.

1b. Collect demographic, mark/tag, and/or genetic (DNA) data, and conduct analyses necessary to indicate the total annual adult contribution, by origin, of Snohomish River basin Chinook salmon to fisheries, hatcheries, and escapements.

1c. Annually report, estimates of adult escapement to natural spawning areas and Basin hatcheries, adult fish contributions to terminal area fisheries by origin (hatchery and natural), estimates of total recruit per spawner levels for the Skykomish and Snoqualmie Chinook salmon populations, potential causative factors (e.g., ocean productivity and freshwater habitat conditions) for hatchery-origin Chinook salmon escapement levels to natural spawning areas (pHOS) relative to natural-origin Chinook salmon escapement levels, and, if available, DNA-analysis based levels of gene flow between naturally spawning hatchery-origin fish and natural-origin fish in the Skykomish and Snoqualmie rivers.

1d. The total number of natural-origin Chinook salmon held each year for spawning at the Wallace River Hatchery shall not exceed 400 fish.

1e. Report when and how many fall Chinook salmon collected post October 1 at Wallace River Hatchery are used for hatchery broodstock at Tulalip Hatchery.

1f. Endeavor to annually decrease the proportion of hatchery-origin Chinook salmon that make up the total number of surplus fish not used as broodstock at Wallace River Hatchery that are released upstream of the Wallace River weir to spawn naturally.

2a. As a means to evaluate predation risks to natural-origin Chinook salmon juveniles, annually monitor, through the ongoing Tulalip tribal juvenile salmonid outmigrant trapping program, the statistical week incidence of hatchery-origin Chinook salmon and coho salmon yearling smolts relative to the total number of Chinook salmon and coho salmon smolts released, respectively, in watershed areas downstream of Wallace River Hatchery and Eagle Creek Hatchery for at least one month after release of the yearlings from the facility.

2b. Collect data regarding the relative proportions, emigration timings, and individual fish sizes, for hatchery-origin yearling Chinook and coho salmon, and natural-origin juvenile Chinook salmon, encountered through trapping in the lower Skykomish River.

2c. Submit any revisions of individual fish release size and timing protocols described in the Wallace River Hatchery HGMPs for yearling Chinook and coho salmon for NMFS concurrence on or before January 1 of each year.

2d. Annually report results of monitoring and data collection activities described in 2a and 2b.

3a. Comply with the NMFS Anadromous Salmonid Passage Facility Design criteria (NMFS 2011c) for water intake structures and screening used by the Wallace River Hatchery programs by fall 2020.
3b. Monitor and annually report all incidences of juvenile natural-origin Chinook salmon and steelhead entrainment and mortality associated with screening at action area hatchery facilities.
3c. Ensure that new water intake structures and associated screening at Wallace River Hatchery do not present risks of entrainment for juvenile fish in more than a total of 4 square meters of migration and rearing area adjacent to the intake structures.

4a. Immediately release unharmed at the point of capture any natural-origin steelhead and bull trout incidentally encountered in the course of salmon broodstock collection operations. Hatchery-origin steelhead, identifiable by a clipped adipose fin, that are collected during salmon broodstock collection operations shall be removed at the point of capture and not returned to waters accessible to ESA-listed steelhead to reduce the threat of genetic and ecological effects to the native Snohomish River basin steelhead populations.
4b. Annually monitor and report the number, location, and deposition of any steelhead and bull trout encountered during salmon broodstock collection operations.

5. Implement the hatchery programs as described in the HGMPs to promote achievement of fish production goals while minimizing impacts on listed Puget Sound Chinook salmon and steelhead. Manage the programs by limiting production to no more than 110% of levels described in the HGMPs, and by releasing hatchery salmon only from the locations described in the HGMPs. NMFS's SFD must be notified in advance of any change in hatchery program operation and implementation that potentially would result in increased take of ESA-listed species.

6. Provide one comprehensive annual report to NMFS SFD on or before April 1st of each year that includes the RM&E for the previous year described in Term and Conditions 1c, 3b, 4b, and 5. The numbers of hatchery-origin salmon released, release dates and locations, and tag/mark information shall be included in the annual report. All reports, as well as all other notifications required in the permit, shall be submitted electronically to the SFD point of contact for this program:

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

Annual reports may also be submitted in written form to:

NMFS – Sustainable Fisheries Division
Anadromous Production and Inland Fisheries Program
510 Desmond Drive Suite 103
Lacey, WA 98503

2.9 Conservation Recommendations

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

1. The co-managers, in cooperation with the NMFS and other entities, should investigate the relative reproductive success, and relative survival, of hatchery- and natural-origin Chinook salmon in the Snohomish River basin to further scientific understanding of the genetic diversity and fitness effects of artificial propagation of the species, particularly, effects resulting from hatchery subyearling Chinook salmon production. Following this research through generations would allow detection of whether observed fitness differences are heritable. The relative contribution of these and other hatchery effects, in context with harvest and habitat effects, on all four viability parameters is being included in a watershed Total Viability Analysis (TVA) under development by the co-managers.

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 to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

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

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

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

3.1 Essential Fish Habitat Affected by the Project

The Proposed Action is implementation of six hatchery salmon programs in the Snohomish River basin, as described in detail in Section 1.3. The action area of the Proposed Action includes habitat described as EFH for Chinook salmon, pink salmon and coho salmon. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the Proposed Action on EFH for the three salmon species for which EFH has been designated. Other fish species for which EFH has been designated in the vicinity of the Action Area, but that would not be affected by the Proposed Action, are identified in Appendix Table 2.

The areas affected by the Proposed Action include the Snohomish River basin from RM 0.0 to the upstream extent of anadromous fish access in the Skykomish River and Snoqualmie river watersheds; Wallace River from its confluence with the Skykomish River at RM 35.7 to the upstream extent of anadromous fish access; Tulalip Creek, tributary to Tulalip Bay, from its mouth to RM 2.5; Battle Creek, tributary to Tulalip Bay, from its mouth to RM 0.1; the South Fork Skykomish River from Sunset Falls at RM 51.5 to the upstream extent of anadromous fish access; and Everett Bay, in the vicinity of Mukilteo, Washington.

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

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

3.2 Adverse Effects on Essential Fish Habitat

The Proposed Action generally does not have substantial effects on the major components of EFH. Adult salmon holding and spawning habitat, and juvenile salmon rearing locations, are not expected to be affected by the operation of the hatchery programs, as no modifications to these areas would occur. Upgraded screening at Wallace River Hatchery to meet current NMFS hatchery facility screening criteria is proposed to occur by fall 2020, and retrofitting of the screens is included as a condition through NMFS's ESA consultation. Potential effects on EFH by the Proposed Action are only likely to occur predominately in Snohomish River basin waters downstream of Wallace River Hatchery where Chinook, coho, and pink salmon migrate and spawn naturally.

Implementation of the Snohomish River basin hatchery programs has the potential to result in some degree of genetic diversity change in hatchery Chinook and coho salmon produced through the programs, in the progeny of naturally spawning hatchery fish, and in the natural populations relative to their baseline diversity and productivity status. Pink salmon are not propagated as part of the hatchery programs, and there would therefore be no hatchery-related genetic effects to pink salmon associated with the Proposed Action. The PFMC (2014) recognized concerns regarding the "genetic and ecological interactions of hatchery and wild fish … [which have] been identified as risk factors for wild populations." The biological opinion describes in considerable detail the impacts hatchery programs might have on natural populations (Section 2.4.1). Additional detail on possible genetic effects of salmon hatchery programs can be found in NMFS (2012b) and Ford et al. (2011). In implementing the Snohomish River basin hatchery salmon programs, the co-managers will apply best management practice risk reduction measures described as part of the proposed actions. These measures, pertaining to broodstock collection, mating, fish rearing, and fish release practices, should adequately reduce the risk that the Wallace River Hatchery Chinook and coho salmon, and the Tulalip Hatchery coho salmon programs will have an adverse effect on the genetic diversity and fitness of Chinook and coho salmon populations in the Snohomish River basin. The co-managers will also monitor and report annual run timing, location, age and sex composition, and origin of escaping Chinook and coho salmon to gauge changes in population traits that may be associated with the hatchery actions. Genetic samples (DNA) will be collected from natural-origin and hatchery-origin Chinook salmon to monitor the genetic diversity status of the Skykomish and Snoqualmie Chinook populations, and genetic divergence between the hatchery and natural-origin Skykomish Chinook aggregations. The co-managers will also analyze genetic samples to determine levels of gene flow between naturally spawning hatchery-origin Chinook salmon and the natural-origin Chinook salmon populations. In addition to enhancing the overall abundance of Skykomish Chinook salmon and Skykomish River coho salmon, the hatchery programs for the species may serve as a genetic reserve for the extant populations in the Basin, as buffers against catastrophic losses of the naturally spawning components. In addition, adult salmon produced through the hatchery programs that escape to natural spawning areas may benefit spatial structure of the populations by augmenting natural spawning abundances in under-seeded areas. These potential benefits would help offset risks to Snohomish River basin Chinook and coho salmon diversity and productivity that may result from natural spawning by hatchery-origin fish at high proportions of total abundances. For these reasons, adverse effects on salmon EFH resulting from genetic effects would be inconsequential.

Naturally spawning adult salmon produced by the proposed hatchery programs may lead to effects on natural-origin salmon EFH through spawning ground competition and redd superimposition. The biological opinion describes general and specific impacts the hatchery programs might have on naturally spawning salmon populations (Section 2.4.1). The intent of the hatchery Chinook and coho salmon programs is to produce native stock adult fish that will return to marine and freshwater commercial and recreational fishing areas to augment harvests. As explained in the biological opinion and the HGMPs for the proposed programs (WDFW 2013a; 2013b; 2013c; Tulalip 2012; 2013a; 2013b), the majority of salmon produced through the programs will be harvested in pre-terminal and terminal area fisheries, reducing the number of salmon that would escape to freshwater EFH. This is especially true for adult salmon produced by the Tulalip Tribes' hatchery programs and returning to Tulalip Bay, where high harvest rate tribal fisheries operate. A substantial proportion of salmon escaping terminal area fisheries home to their hatchery releases sites, further reducing the number hatchery salmon that escape into natural spawning areas that are part of EFH in the basin. Very few coho salmon and fall chum salmon adults originating from the hatchery programs are expected to escape Tulalip Bay fisheries to natural spawning areas comprising EFH. Further, any naturally spawning hatchery coho and fall chum salmon would not overlap temporally and spatially to a substantial degree with natural-origin Chinook, coho, or pink salmon in natural spawning areas, so there would be no effects on spawning, or redds created by, those species. The co-managers will monitor and report hatchery-origin salmon escapements to gauge changes on EFH that may result from the hatchery actions.

The release of yearling Chinook and coho salmon through programs at Wallace River Hatchery (including coho salmon releases from Eagle Creek Hatchery) may lead to effects on EFH through predation on juvenile Chinook, coho, and pink salmon. Juvenile salmon produced through the Tulalip Tribes' salmon hatchery programs would be released as smolts or fry into Tulalip Bay or Tulalip Bay watershed freshwater areas lacking listed natural-origin salmonid populations, and there would be no effects on salmon EFH from the tribal Chinook, coho, and fall chum salmon programs. Coho salmon yearlings from the Everett Bay Net-pen program would be released directly into seawater, and there would be no effects on freshwater salmon EFH. The risk of hatchery-origin smolt predation on natural-origin juvenile fish in freshwater is dependent upon three factors: 1) the hatchery fish and their potential natural-origin prey must overlap temporally; 2) the hatchery fish and their prey must overlap spatially; and, 3) the prey should be less than 1/3 the length of the predatory fish.

Through a comparison of relative individual sizes and freshwater occurrence timings for emigrating natural-origin juvenile Chinook, coho, and pink salmon, and hatchery-origin Chinook and coho salmon juveniles released from WDFW-administered programs in the watershed, NMFS determined in its opinion that the hatchery-origin species and life stages with substantial spatial and temporal overlap with smaller juvenile listed Chinook salmon, posing the highest risk for predator-prey interactions, would be Wallace River Hatchery yearling Chinook and coho salmon and Eagle Creek Hatchery coho salmon. Subyearling Chinook salmon are released from Wallace River Hatchery after the majority of natural-origin Chinook, coho, and pink salmon have emigrated seaward, and the risk of interactions that would lead to predation is unsubstantial. Additionally, hatchery-origin subyearling Chinook salmon are too small in individual size to consume any co-occurring natural-origin salmonids of life stages that would be present in downstream areas during June, when the hatchery fish are released (see Table 17 in the NMFS opinion). An elevated risk for predation effects on salmon EFH for Wallace River Hatchery and Eagle Creek Hatchery yearling releases is assigned based on the upper watershed release location (RM 39.7 in the Skykomish River/Snohomish River/Wallace River watershed, and RM 28.3 in the Skykomish River/Snohomish River watershed, respectively), and large individual fish size relative to the size of natural-origin juvenile Chinook salmon that may be encountered during the spring-time release periods for the hatchery-origin fish. In the opinion, NMFS evaluated the risk of predation to juvenile salmonids associated with the Wallace River Hatchery and Eagle Creek Hatchery yearling programs, and determined that any effects would be unsubstantial, and adequately reduced thorough implementation of fish release practices proposed in the HGMPs. Available data in Puget Sound indicate that newly released hatchery-origin yearling salmon are not highly piscivorous. The practice of releasing actively migrating yearling smolts only, during freshets, in April and May would limit the duration for interactions between hatchery-origin yearling Chinook and coho salmon and juvenile natural-origin salmon in downstream areas. Because juvenile out-migrant trapping data in the Skykomish River indicate that the hatchery-origin yearlings would disperse rapidly downstream and seaward from freshwater areas where any rearing and migrating natural-origin salmon would be most concentrated within hours or a few days post-release, opportunities for predation would be unsubstantial. For these reasons, effects are likely inconsequential to Chinook, coho, and pink salmon EFH. The co-managers will monitor and report hatchery-origin yearling and natural-origin juvenile salmon abundance, timing, and temporal overlap data collected through an annual juvenile out-migrant trapping program in the lower Skykomish River authorized for takes through a separate ESA consultation. This monitoring effort will allow for evaluation of interactions and predation risks, and the need for adjustment of yearling Chinook and coho release programs to further reduce predation risks.

Regarding hatchery facility operation effects on salmon EFH, the Wallace River Hatchery water intake screens on Wallace River and May Creek are in compliance with state and federal guidelines (NMFS 1995, 1996), but the screens do not meet current NMFS Anadromous Salmonid Passage Facility Design Criteria (NMFS 2011c) designed to protect natural-origin salmon from injury and mortality. WDFW has indicated the intent in their HGMPs to modify screening at Wallace River Hatchery to comply with NMFS screening requirements to protect natural-origin fish from entrainment and impingement that may lead to injury and mortality. Intake screens on both tributaries are scheduled by WDFW for rebuild by fall 2020 to bring the screens into compliance with those criteria and to reduce risks to salmon EFH. Proposed retrofitting of the Wallace River Hatchery screens to be in compliance with current NMFS criteria should adequately reduce risks to listed Chinook salmon and steelhead in the Wallace River watershed. Screening at the Tulalip Tribes' hatchery facilities is not a risk factor to EFH, as there are no natural-origin salmon fish populations in the small tributaries to Tulalip Bay where the facilities are located. The Everett Bay Net-Pen program would operate using mesh sizes on the net-pen containing hatchery-origin coho salmon smolts (WDFW 2013c) that do not pose any measurable risks of entrainment and mortality to salmon, and would have no effects on salmon EFH. Through the NMFS biological opinion, in up-grading screens, WDFW will comply with NMFS Anadromous Salmonid Passage Facility Design criteria (NMFS 2011c) by fall 2020. They will monitor and annually report all incidences of juvenile natural-origin Chinook salmon and steelhead entrainment and mortality associated with screening at Wallace River Hatchery. For these reasons, screens at the Wallace River Hatchery facility will pose a negligible risk to EFH for salmon in the Snohomish River basin (sec section 2.4.2).

3.3 Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the Proposed Action on EFH for Chinook, coho, and pink salmon, NMFS believes that the Proposed Action, as described in the HGMPs (Tulalip 2012; 2013a; 2013b; WDFW 2013a; 2013b; 2013c) and the ITS (Section 2.8), includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS constitute NMFS recommendations to address potential EFH effects. NMFS and BIA shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, are carried out.

To address the potential effects on EFH of hatchery fish on natural fish in natural spawning and rearing areas, the PFMC (2014) provided an overarching recommendation that hatchery programs:

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

The biological opinion explicitly discusses the potential risks of hatchery fish on fish from natural populations and their ecosystems, and describes operation and monitoring appropriate to minimize these risks on Chinook, coho, and pink salmon in the Snohomish River basin.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations, unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

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

3.5 Supplemental Consultation

The FWS and BOR 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 six Snohomish River basin 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 Tulalip Tribes and WDFW (operators); NMFS (regulatory agency), and BIA (indirect funding entity). The scientific community, resource managers, and stakeholders benefit from the consultation through adult returns of program-origin salmon to the Snohomish River basin and Puget Sound, and through the collection of data indicating the potential effects of the hatchery programs on the viability of natural populations of Puget Sound Chinook salmon and Puget Sound steelhead. This information will improve scientific understanding of hatchery-origin salmon effects on natural populations 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 Northwest Region web site (http://www.nwr.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 Northwest Region ESA quality control and assurance processes.

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Appendix Table 1. Puget Sound Salmon and Steelhead HGMP Bundles, and their ESA and NEPA Review Status. August 21, 2017

HGMP Name HGMPs are organized into groups for more efficient review purposes	Proposal Submitted for NMFS Review	Applicants	Is HGMP Sufficient for ESA Review? 1/	Review Status	ESA/NEPA Completion Date
Hood Canal Summer Chum Salmon				4(d) Limit 5 ERDs, BiOp, and EA complete.	**COMPLETE** July 2002
Quilcene NFH Supplementation		USFWS			
Hamma Hamma FH Supplementation		USFWS			
Lilliwaup Creek Supplementation		USFWS			
Union/Tahuya Supplement./Reintroduction		USFWS			
Big Beef Creek Reintroduction		WDFW			
Chimacum Creek Reintroduction		WDFW			
Jimmycomelately Creek Reintroduction		WDFW			
Salmon Creek Supplementation		WDFW			
Lake Ozette Sockeye Salmon Umbrella Ck Supplementation/Reintroduction		Makah		4(d) Limit 6 ERD, BiOp, and EA complete. Reinitiated BiOp complete.	**COMPLETE** May 2003 June 2015
Elwha					
Lower Elwha Hatchery Native Steelhead		Lower Elwha		ESA and NEPA compliance issued in December 2012. The ESA (Limit 6 PEPD) and NEPA decision documents were updated as per a Federal Court opinion.	**COMPLETE** Dec 2012 **COMPLETE** (Reinitiation) Dec 2014
Lower Elwha Hatchery Elwha Coho		Lower Elwha			
Elwha Channel Hatchery Chinook		WDFW			
Lower Elwha Hatchery Elwha Chum		Lower Elwha			
Lower Elwha Hatchery Pink		Lower Elwha			

HGMP Name **HGMPs are organized into groups for more efficient review purposes**	**Proposal Submitted for NMFS Review**	**Applicants**	**Is HGMP Sufficient for ESA Review? 1/**	**Review Status**	**ESA/NEPA Completion Date**
Dungeness					
Dungeness River Hatchery Spring Chinook		WDFW		4(d) Limit 6 ERD, BiOp, and EA/FONSI complete.	**COMPLETE** June 2016
Dungeness River Hatchery Coho		WDFW			
Dungeness River Hatchery Fall Pink		WDFW			
Snohomish					
Tulalip Hatchery Chinook Sub-yearling	12-20-12	Tulalip	Yes	Final EA/FONSI complete. BiOp and 4(d) ERD awaiting ***final*** NMFS internal and GCNW reviews	Fall 2017
Wallace River Hatchery Summer Chinook	2-19-13	WDFW			
Wallace River Hatchery Coho	10-14-13	WDFW			
Tulalip Hatchery Coho	6-21-13	Tulalip			
Tulalip Hatchery Fall Chum	6-21-13	Tulalip			
Everett Bay Net-Pen Coho	6-27-13	WDFW			
Early Winter Steelhead #1					
Kendall Creek Winter Steelhead		WDFW		4(d) Limit 6 ERDs, BiOps, FEIS/ROD, and USFWS (bull trout) consultation complete.	**COMPLETE** April 2016
Dungeness River Early Winter Steelhead		WDFW			
Whitehorse Ponds Winter Steelhead		WDFW			
Early Winter Steelhead #2 [3]					
Snohomish/Skykomish Winter Steelhead		WDFW			
Snohomish/Tokul Creek Winter Steelhead		WDFW			

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HGMP Name HGMPs are organized into groups for more efficient review purposes	Proposal Submitted for NMFS Review	Applicants	Is HGMP Sufficient for ESA Review? 1/	Review Status	ESA/NEPA Completion Date
Hood Canal					**COMPLETE** October 2016
Hoodsport Fall Chinook	7-29-14	WDFW	Yes	4(d) Limit 6 ERD, BiOp, and EA/FONSI complete. USFWS (bull trout) consultation complete	
Hoodsport Fall Chum	1-11-13	WDFW			
Hoodsport Pink	1-11-13	WDFW			
Enetai Hatchery Fall Chum	9-23-13	Skokomish			
Quilcene NF Hatchery Coho	7-15-13	USFWS			
Quilcene Bay Net-Pens Coho	9-18-13	Skokomish/USFWS			
Port Gamble Bay Net-Pens Coho	3-5-13	Pt Gamble S'Klallam/USFWS			
Port Gamble Hatchery Fall Chum	3-5-13	Pt Gamble S'Klallam			
Hamma Hamma Chinook Salmon	5-1-13	WDFW			
Hood Canal Steelhead Supplementation	4-3-13	WDFW			
Duwamish/Green					Fall 2017
Soos Creek Hatchery Fall Chinook	4-3-13	WDFW	Yes	All HGMPs "Sufficient"; Draft EIS in preparation	
Keta Creek Coho (w/Elliot Bay Net-pens)	12-17-14	Muckleshoot/Suquam.			
Soos Creek Hatchery Coho	7-29-14	WDFW			
Keta Creek Hatchery Chum	12-17-14	Muckleshoot			
Marine Technology Center Coho	11-18-14	WDFW			
Fish Restoration Facility (FRF) Coho	12-17-14	Muckleshoot			
Fish Restoration Facility (FRF) Chinook	12-17-14	Muckleshoot			
Fish Restoration Facility (FRF) Steelhead	12-17-14	Muckleshoot			
Green River Wild Winter Steelhead Program	11-18-14	WDFW			
Soos Creek Hatchery Summer Steelhead	12-14-15	WDFW			

HGMP Name HGMPs are organized into groups for more efficient review purposes	Proposal Submitted for NMFS Review	Applicants	Is HGMP Sufficient for ESA Review? 1/	Review Status	ESA/NEPA Completion Date
Puyallup/White					Fall 2017
Clarks Creek Hatchery Chinook	11-29-12	Puyallup	Yes	All HGMPs "Sufficient"; Draft EIS in preparation	
Voights Creek Hatchery Chinook	4-3-13	WDFW			
Voights Creek Hatchery Coho	6-27-13	WDFW			
Diru Creek Hatchery Winter Chum	5-1-13	Puyallup			
Diru Creek Hatchery Late Coho	5-1-13	Puyallup			
White R. Hatchery/Acclimation Ponds Chinook	12-17-14	Muckleshoot/Puyallup			
White R. Winter Steelhead Supplementation	12-17-14	Muckleshoot/Puyallup			
Minter/Hupp White River Spring Chinook	7-29-16	WDFW			
Nooksack/Georgia Strait					Fall 2017
Whatcom Creek Hatchery Pink	1-25-16	WDFW	Yes	All HGMPs "Sufficient"; Draft EIS in preparation	
Whatcom Creek Hatchery Chum	1-25-16	WDFW			
Glenwood Springs Hatchery Fall Chinook	5-2-13	WDFW			
Kendall Creek Hatchery NF Spring Chinook	1-25-16	WDFW			
Kendall Creek Hatchery Chum	1-25-16	WDFW			
Samish River Hatchery Fall Chinook	1-25-16	WDFW			
Skookum Creek Hatchery SF Early Chinook	1-25-16	Lummi			
Skookum Creek Hatchery Coho	1-25-16	Lummi			
Lummi Bay Hatchery Chum	1-25-16	Lummi			
Lummi Bay Hatchery Coho	1-25-16	Lummi			
Lower Nooksack Fall Chinook	1-25-16	Lummi			

HGMP Name HGMPs are organized into groups for more efficient review purposes	Proposal Submitted for NMFS Review	Applicants	Is HGMP Sufficient for ESA Review? 1/	Review Status	ESA/NEPA Completion Date
Stillaguamish					
Stillaguamish Fall Chinook Natural Stock Restoration	9-4-15	Stillaguamish	Under review	All HGMPs "Sufficient" (August 9, 2017)	
Stillaguamish Summer Chinook Natural Stock Restoration	9-4-15	WDFW/Stillaguamish	Under review		
Stillaguamish Late Coho	8-29-16	Stillaguamish	Under review		
Stillaguamish Fall Chum	8-29-16	Stillaguamish	Under review		
Deep South Sound					
Minter Creek Hatchery Coho	1-4-13	WDFW	Yes	All HGMPs "Sufficient" (March 4, 2016), but awaiting receipt of revised comanager-consensus Chambers Creek Fall Chinook HGMP	
Minter Creek Hatchery Chum	1-4-13	WDFW			
Minter Creek Fall Chinook	5-1-13	WDFW			
Tumwater Falls Chinook	5-1-13	WDFW			
Chambers Creek Fall Chinook	5-27-15	WDFW			
Squaxin/South Sound Net-Pens Coho	3-14-17	Squaxin/WDFW			
Skagit River					
Upper Skagit Hatchery Chum	8-27-15	Upper Skagit	Yes	All HGMPs "Sufficient" (August 4, 2016)	Summer 2018
Skagit River Spring Chinook	8-27-15	WDFW			
Skagit River Summer Chinook	8-27-15	Skagit Coop/WDFW			
Skagit River Coho	8-27-15	WDFW			
Baker River Sockeye	8-27-15	PSE/WDFW			

HGMP Name HGMPs are organized into groups for more efficient review purposes	Proposal Submitted for NMFS Review	Applicants	Is HGMP Sufficient for ESA Review? 1/	Review Status	ESA/NEPA Completion Date
Baker River Coho	8-27-15	PSE/WDFW			
Baker River Steelhead Reservoir Pass. Research	8-27-15	Upper Skagit			
Chum Remote Site Incubator	8-27-15	Sauk-Suiattle			
Skokomish River [4]					
McKernan Hatchery Chum	1-11-13	WDFW	Yes	Review pending receipt of HGMPs for NF Skok Coho & Cushman Sockeye programs, and revised HGMPs for the NF Skok Spring Chinook and NF Skok Steelhead programs.	
George Adams Fall Chinook	11-18-14	WDFW	Under review		
George Adams Coho	1-11-13	WDFW	Under review		
NF Skokomish Hatchery Coho		TPU, WDFW, Skokomish	Not received		
NF Skokomish Hatchery Steelhead	4-1-16	TPU, WDFW, Skokomish	Revising		
NF Skokomish Hatchery Spring Chinook	3-11-15	TPU, WDFW, Skokomish	Revising		
Cushman (Sportsman's Park) Sockeye		TPU, WDFW, Skokomish	Not received		
Nisqually River					
Nisqually FH Clear Creek/Kalama Creek Fall Chinook	11-13-14	Nisqually	Under review	New working draft version sent to NMFS on 11/10/16	
Kalama Creek Coho		Nisqually	No [2]		

HGMP Name HGMPs are organized into groups for more efficient review purposes	Proposal Submitted for NMFS Review	Applicants	Is HGMP Sufficient for ESA Review? 1/	Review Status	ESA/NEPA Completion Date
Skamania (Summer) Steelhead				WDFW has yet to submit updated HGMPs for these programs	
Reiter Ponds Summer Steelhead	Status Unknown	WDFW	No [2]		
Whitehorse Ponds Summer Steelhead	Status Unknown	WDFW	No [2]		
East Kitsap					
Gorst Creek Fall Chinook		Suquamish	No [2]		
Grovers Creek Hatchery Fall Chinook	3-12-13	Suquamish	Under review		
Cowling Creek Chum Salmon		Suquamish	No [2]		
Agate Pass Net-Pens Coho		Suquamish	No [2]		
Lake Washington					
Issaquah Hatchery Fall Chinook		WDFW	No [2]		
Issaquah Hatchery Coho	12-18-14	WDFW	Under review		
Cedar River Hatchery Sockeye	12-18-14	WDFW	Under review		

[1] "Sufficient" means that an HGMP meets the criteria listed at 50 CFR 223.203(b)(5)(i), which include (1) the purpose of the hatchery program is described in meaningful and measureable terms, (2) available scientific and commercial information and data are included, (3) the Proposed Action, including any research, monitoring, and evaluation, is clearly described both spatially and temporally, (4) application materials provide an analysis of effects on ESA-listed species, and (5) preliminary review suggests that the program has addressed criteria for issuance of ESA authorization such that public review of the application materials

would be meaningful. However, it does not prejudge the outcome of NMFS' review to determine whether the program meets the standard for an exemption from the ESA's §9 prohibitions.

[2] Previously submitted draft plan has not been updated as a co-manager consensus plan to address effects of the proposed hatchery actions on ESA-listed steelhead.

[3] The Soos Creek Hatchery Winter Steelhead HGMP sent 11-12-14 and previously included in the Early Winter Steelhead #2 bundle was withdrawn by the co-managers from ESA consideration on 7-8-15.

[4]Table provided by the co-managers on February 18, 2015 proposes to break-out the WDFW George Adams and McKernan HGMPs from the other plans proposed for the Skokomish River watershed, prioritizing the WDFW HGMPs for processing before the Duwamish/Green HGMP bundle. Awaiting further direction from the co-managers about this proposal.

Appendix Table 2. Species of fishes with designated EFH occurring in the Salish Sea and Northeast Pacific Ocean.

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