DRAFT ENVIRONMENTAL IMPACT STATEMENT

Draft Environmental Impact Statement for 10 Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin

Prepared by the
National Marine Fisheries Service, West Coast Region

NOAA FISHERIES

In Cooperation with the
Bureau of Indian Affairs, Northwest Regional Office

October 2017

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

October 24, 2017

Dear Madam or Sir:

In accordance with provisions of the National Environmental Policy Act (NEPA), we announce the availability for review of the *Draft Environmental Impact Statement for 10 Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin*. The document is accessible electronically through the NMFS West Coast Region's website at http://www.westcoast.fisheries.noaa.gov/hatcheries/salmon_and_steelhead_hatcheries.html. Hard copies or CD copies of the document may be obtained from the comment coordinator, Mr. Steve Leider, at the contact information provided below.

This Draft Environmental Impact Statement (DEIS) assesses environmental impacts associated with the National Marine Fisheries Service's (NMFS) review and approval of 10 hatchery and genetic management plans (HGMPs) submitted jointly by the fishery co-managers for hatchery programs in the Duwamish-Green River Basin in Puget Sound. The HGMPs have been submitted for approval as resource management plans under Limit 6 of the Endangered Species Act 4(d) rules for listed salmon and steelhead.

Written comments may be submitted to NMFS via the comment coordinator below, during the public-comment period (the closing date for the public comment period is noted at the above website). When submitting comments by email or fax, please include the identifier "**Green Hatcheries EIS**" on the subject line or cover page.

Thank you in advance for your vital assistance in ensuring that our HGMP evaluation is sound and based upon the best available information.

Comment Coordinator:

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West Coast Region
510 Desmond Drive SE, Suite 103
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Sincerely,

Barry A. Thom
Regional Administrator

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Cover Sheet

Title of Environmental Review:	Draft Environmental Impact Statement for 10 Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin
Responsible Agency and Official:	Barry A. Thom, Regional Administrator National Marine Fisheries Service, West Coast Region 7600 Sand Point Way NE, Building 1 Seattle, WA 98115
Cooperating Agency:	U.S. Department of the Interior, Bureau of Indian Affairs
Contact:	Steve Leider NMFS Sustainable Fisheries Division, West Coast Region 510 Desmond Drive SE, Suite 103 Lacey, WA 98503 Steve.Leider@noaa.gov (Note: not for commenting) (360) 753-4650
Location of Proposed Activities:	The Duwamish-Green River Basin in Puget Sound, Washington State
Proposed Action:	NMFS would make a determination that the 10 hatchery and genetic management plans (HGMPs) submitted as a resource management plan (RMP) by the co-managers, meet the requirements under Limit 6 of 4(d) Rule under the Endangered Species Act (ESA) for listed Puget Sound Chinook salmon and steelhead.
Abstract:	The Washington Department of Fish and Wildlife and the Puget Sound treaty tribes jointly submitted 10 HGMPs for salmon and steelhead hatchery programs in the Duwamish-Green River Basin in Puget Sound, as an RMP. These plans describe each hatchery program in detail, including fish life stages produced and potential measures to minimize risks of negative impacts that may affect listed fish. NMFS' determination of whether the plans achieve the conservation standards of the ESA, as set forth in Limit 6 of the 4(d) Rule for listed salmon and steelhead, is the Federal action requiring National Environmental Policy Act (NEPA) compliance. The analysis within the environmental impact statement (EIS) informs NMFS, hatchery operators, and the public about the current and anticipated direct, indirect, and cumulative environmental effects of operating the 10 salmon and steelhead hatchery programs under the full range of alternatives.

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Summary

Draft Environmental Impact Statement for 10 Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin

Introduction

Salmon and steelhead have been produced in Puget Sound hatcheries since the early 1900s. The benefit of hatcheries at the outset was to produce hatchery-origin fish for harvest purposes. Hatcheries have contributed 70 to 80 percent of the catch in coastal salmon and steelhead fisheries. As the fish's natural habitat was degraded by human development and activities like passage barriers, forest practices, and urbanization, the role of hatcheries shifted toward mitigation for lost natural production and reduced harvest opportunity. Hatchery production presents risks to natural-origin salmon and steelhead. These include genetic risks from hatchery-origin fish to natural-origin fish as a result of poor broodstock and rearing practices, risks of competition with and predation on naturally spawned populations, and incidental harvest of natural-origin fish in fisheries targeting hatchery-origin fish.

The Washington Department of Fish and Wildlife (WDFW), Muckleshoot Indian Tribe, and Suquamish Tribe (hereafter referred to as the co-managers) have jointly submitted to the National Marine Fisheries Service (NMFS) hatchery and genetic management plans (HGMPs) for 10 hatchery programs that would produce salmon and steelhead in the Duwamish-Green River Basin in Puget Sound. The HGMPs describe the hatchery programs, including fish life stages produced and potential research, monitoring, and evaluation actions to minimize the risk of negatively affecting listed salmon and steelhead (Table S-1). The HGMPs have been submitted for review and approval as a resource management plan (RMP) under Limit 6 of the 4(d) Rule under the Federal Endangered Species Act (ESA). The plans are consistent with the framework of *United States v. Washington* (1974) for coordination of treaty fishing rights, non-tribal harvest, artificial production objectives, and artificial production levels.

Table S-1. ESA status of listed Puget Sound salmon and steelhead.

Species	Evolutionarily Significant Unit/ Distinct Population Segment	Current Endangered Species Act Listing Status
Chinook salmon (*Oncorhynchus tshawytscha*)	Puget Sound	Threatened (76 Fed. Reg. 50448, August 15, 2011)
Chum salmon *(O. keta)*	Hood Canal summer-run (includes Strait of Juan de Fuca summer-run)	Threatened (76 Fed. Reg. 50448, August 15, 2011)
Steelhead (*O. mykiss*)	Puget Sound	Threatened (76 Fed. Reg. 50448, August 15, 2011)
Coho salmon (*O. kisutch*)	Puget Sound/Strait of Georgia	Species of Concern (69 Fed. Reg. 19975, April 15, 2004)

Source: NMFS

NMFS' determination of whether the HGMPs submitted as an RMP achieve the conservation standards of the ESA, as set forth in Limit 6 of the 4(d) Rule, is the Federal action requiring National Environmental Policy Act (NEPA) compliance. Although this environmental impact statement (EIS) itself will not determine whether the HGMPs submitted as an RMP meet ESA requirements—those determinations are made under the specific criteria of the ESA and the 4(d) Rule—the analyses within the EIS will inform NMFS, hatchery operators, and the public about the current and anticipated cumulative environmental effects of operating the 10 salmon and steelhead hatchery programs under the full range of alternatives.

Proposed Action

Under the Proposed Action, NMFS would determine whether the 10 HGMPs submitted as an RMP, meet the requirements of Limit 6 of the 4(d) Rule. The HGMPs for Puget Sound hatcheries would be implemented by the co-managers.

Project Area

The project area covered in this EIS includes the places where the proposed salmon and steelhead hatchery programs would (1) collect broodstock; (2) spawn, incubate, and rear fish; (3) release fish; or (4) remove surplus hatchery-origin adult salmon and steelhead that return to hatchery facilities; and (5) conduct monitoring and evaluation activities. The project area consists of the Duwamish-Green River Basin. These 10 hatchery programs (7 seven current and 3 new hatchery programs) would operate using four hatchery facilities, three rearing ponds, and two net pens, and would produce up to 13,993,000 juvenile salmon and steelhead per year.

> **What is the 4(d) Rule?**
>
> Section 4(d) of the ESA directs NMFS to issue regulations to conserve species listed as threatened. This applies particularly to "take," which can include any act that kills or injures fish, and may include habitat modification. The ESA prohibits any take of species listed as endangered; however, some take of threatened species that does not interfere with survival and recovery may be allowed.
>
> For salmon and steelhead, the 4(d) Rule applies take prohibitions to all actions except those within the 13 limits to the rule. The limits, or exemptions, describe specified categories of activities that contribute to conserving listed salmon. A separate, but closely related, tribal 4(d) Rule creates an additional limit for tribal RMPs.
>
> Limit 5 of the 4(d) Rule, using specific criteria, provides limits on the prohibitions of "take" for a variety of hatchery purposes, based on NMFS' evaluation and approval of HGMPs submitted by hatchery operators. Limit 6 of the 4(d) Rule provides limits on the prohibitions of "take" for joint tribal and state plans developed under *United States v. Washington* processes, including artificial production actions.

Purpose and Need

The purpose of the Proposed Action from NMFS' perspective is to evaluate the submitted HGMPs for ESA compliance. The need for the Proposed Action is to ensure the sustainability and recovery of Puget Sound salmon and steelhead by conserving the productivity, abundance, diversity, and distribution of listed species of salmon and steelhead in Puget Sound. NMFS will ensure it meets its tribal trust stewardship responsibilities and will also work collaboratively with the Muckleshoot Indian Tribe, Suquamish Tribe, and WDFW to protect and conserve listed species.

The co-managers' objectives in developing and submitting HGMPs and submitting them as an RMP under Limit 6 of the 4(d) Rule is to operate their hatcheries to meet resource management and protection goals with the assurance that any harm, death, or injury to fish within a listed evolutionarily significant unit (ESU) or distinct population segment (DPS) does not appreciably reduce the likelihood of a species' survival and recovery and is not in the category of prohibited take under the 4(d) Rule.

What is an ESU? What is a DPS?

NMFS lists salmon as threatened or endangered according to the status of their evolutionarily significant units (ESUs). An ESU is a salmon population that is 1) substantially reproductively isolated from conspecific populations and 2) represents an important component of the evolutionary legacy of the species.

In contrast to salmon, NMFS lists steelhead under the joint NMFS-U.S. Fish and Wildlife Service (USFWS) policy for recognizing distinct population segments (DPSs) under the ESA. This policy adopts criteria similar to, but somewhat different than, those in the ESU policy for determining when a group of vertebrates constitutes a DPS. A group of organisms is discrete if it is “markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors.” NMFS lists steelhead according to the status of the steelhead DPS.

The co-managers also have as an objective the continued operation of salmon and steelhead hatchery programs using existing facilities for conservation, mitigation, and tribal and non-tribal fishing opportunity pursuant to the Puget Sound Salmon Management Plan implemented under *United States v. Washington*, and treaty rights preservation purposes while meeting ESA requirements. WDFW and the Puget Sound treaty tribes strive to protect, restore, and enhance the productivity, abundance, and diversity of Puget Sound salmon and steelhead and their ecosystems to sustain treaty ceremonial and subsistence fisheries, treaty and non-treaty commercial and recreational fisheries, non-consumptive fish benefits, and other cultural and ecological values.

Relationship between the ESA and NEPA

The relationship between the ESA and NEPA is complex, in part because both laws address environmental values related to the impacts of a Proposed Action. However, each law has a distinct purpose, and the scope of review and standards of review under each statute are different.

The purpose of an EIS under NEPA is to promote disclosure, analysis, and consideration of the broad range of environmental issues surrounding a proposed major Federal action by considering a full range of reasonable alternatives, including a No-action Alternative. Public involvement promotes this purpose. The purpose of the ESA is to conserve listed species and the ecosystems upon which they depend. Determinations about whether hatchery programs in Puget Sound meet ESA requirements are made under section 4(d) or section 7 of the ESA. Each of these ESA sections has its own substantive requirements, and the documents that reflect the analyses and decisions are different than those related to a NEPA analysis.

It is not the purpose of this EIS to suggest to the reader any conclusions relative to the ESA analysis for this action. While the NEPA Record of Decision (ROD) identifies the selected NEPA alternative, the ROD does not conclude whether that alternative complies with the ESA.

Alternatives Analyzed in Detail

Alternative 1 (No Action)

Under this alternative, NMFS would not make a determination under the 4(d) Rule for any of the 10 HGMPs, and the hatchery programs would not be exempted from ESA section 9 take prohibitions. Although other outcomes are possible, for the purposes of this EIS, NMFS has defined the No-action Alternative as the choice by the applicants to continue the hatchery programs without ESA authorization. The three new fish restoration facility (FRF) programs would produce up to 1,550,000 juveniles, and the locations and life stages of fish released from these programs would differ depending on whether fish passage facilities are provided at Howard Hanson Dam. Up to 13,993,000 salmon and steelhead juveniles would be released from the 10 hatchery programs annually (Table S-2). No new environmental protection or enhancement measures would be implemented.

Table S-2. Maximum annual hatchery releases of juvenile salmon and steelhead in the Duwamish-Green River Basin under the alternatives.

Species	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Fall-run Chinook Salmon	5,100,000	5,100,000	0	2,550,000
Late Winter-run Steelhead	383,000	383,000	0	191,500
Summer-run Steelhead	100,000	100,000	0	50,000
Coho Salmon	3,410,000	3,410,000	0	1,705,000
Chum Salmon	5,000,000	5,000,000	0	2,500,000
Total	**13,993,000**	**13,993,000**	**0**	**6,996,500**

Source: HGMPs.

Alternative 2 (Proposed Action)

This alternative consists of hatchery operations as proposed under the co-managers' HGMPs. NMFS would make a determination that the HGMPs submitted by the co-managers meet requirements of the 4(d) Rule. The salmon and steelhead hatchery programs in the Duwamish-Green River Basin would be implemented as described in the 10 submitted HGMPs (Table S-2), and, as under Alternative 1, up to 13,993,000 salmon and steelhead juveniles would be released annually. The hatchery programs would use hatchery capacity as described in the HGMPs for operations, and would be adaptively managed over time to incorporate best management practices as new information is available.

Alternative 3 (Termination)

Under this alternative, NMFS would make a determination that the HGMPs as proposed do not meet the standards prescribed under Limit 5 and Limit 6 of the 4(d) Rule, and the 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin would be terminated. All salmon and steelhead being raised in hatchery facilities (i.e., fall-run Chinook salmon, late winter-run steelhead, summer-run steelhead, coho salmon, and chum salmon) would be released or killed, and no broodstock would be collected.

NMFS' regulations under the 4(d) Rule do not provide NMFS with the authority to order changes of this magnitude as a condition of approval of the HGMPs submitted as an RMP. NMFS' regulations under the 4(d) Rule require NMFS to make a determination that the HGMPs submitted as an RMP *as proposed* either meet or do not meet the standards prescribed in the rule. Nonetheless, NMFS supports analysis of this alternative to assist with a full understanding of potential effects on the human environment under various management scenarios.

Alternative 4 (Reduced Production)

Under this alternative, the applicants would reduce the number of fish released from each of the 10 proposed hatchery programs by 50 percent (to 6,996,500 salmon and steelhead juveniles) because it represents a mid-point between the Proposed Action (Alternative 2) and termination of the hatchery programs (Alternative 3) (Table S-2). Revised HGMPs would be submitted reflecting these reduced production levels, and NMFS would make a determination that the revised HGMPs submitted as an RMP meet the requirements of the 4(d) Rule.

NMFS' regulations under the 4(d) Rule do not provide NMFS with the authority to order changes of this magnitude as a condition of approval of the HGMPs submitted as an RMP. NMFS' regulations under the 4(d) Rule require NMFS to make a determination that the HGMPs submitted as an RMP *as proposed* either meet or do not meet the standards prescribed in the rule. Nonetheless, NMFS supports analysis of this alternative to assist with a full understanding of potential effects on the human environment under various management scenarios.

A summary of distinguishing features of the alternatives is shown in Table S-3.

Table S-3. Summary of distinguishing features of the alternatives.

Alternative	NMFS Review, Evaluation, and Approval of Plans under the 4(d) Rule	Number of Hatchery-origin Fish Released	Changes in Hatchery Programs	Conservation Benefit to Salmon and Steelhead
Alternative 1 (No Action)	No evaluation and determination under the 4(d) Rule	13,993,000	Similar to existing conditions, except that three new Fish Restoration Facility (FRF) programs would be implemented. Hatchery programs would not be exempt from ESA section 9 take prohibitions. No new environmental protection or enhancement measures would be implemented.	Conservation requirements for listed salmon and steelhead would not be met.
Alternative 2 (Proposed Action)	Evaluation and determination under the 4(d) Rule	13,993,000	Production levels would continue, and conservation measures would be applied to salmon and steelhead hatchery programs to reduce risks and to meet conservation requirements.	Conservation requirements for listed salmon and steelhead would be met.
Alternative 3 (Termination)	Not applicable	0	Hatchery-origin salmon and steelhead programs would be terminated.	Conservation requirements for listed salmon and steelhead would be met, and most risks from hatchery programs would be eliminated over time.
Alternative 4 (Reduced Production)	Same as Alternative 2	6,996,500	Releases of hatchery-origin salmon and steelhead would be reduced 50 percent compared to Alternative 1 and Alternative 2.	Conservation requirements for listed salmon and steelhead would be met.

Summary of Resource Effects

Table S-4 provides a summary of the predicted resource effects under each of the four alternatives. The summary reflects the detailed resource discussions in Chapter 4, Environmental Consequences.

The relative magnitude and direction of impacts is described in Table S-4 using the following terms:

Undetectable:	The impact would not be detectable.
Negligible:	The impact would be at the lower levels of detection, and could be either positive or negative.
Low:	The impact would be slight, but detectable, and could be either positive or negative.
Moderate:	The impact would be readily apparent, and could be either positive or negative.
High:	The impact would be greatly positive or severely negative.

Preferred Alternative

This draft EIS does not contain a preferred alternative. NMFS will identify the preferred alternative in the final EIS after considering the comments received on this draft EIS. The preferred alternative may be one of the alternatives or a combination of components of more than one alternative, possibly varying for each hatchery program.

How should reviewers approach this EIS?

NMFS encourages reviewers to:

1. Review the draft EIS to gain an understanding of how it is organized and how the alternatives are framed and analyzed.
2. Carefully consider the information provided in Chapter 4, Environmental Consequences, and Chapter 5, Cumulative Effects.
3. After considering the effects, comment on how NMFS should formulate a preferred alternative for publication in the final EIS and ROD.

Table S-4. Summary of environmental consequences for EIS alternatives by resource.

Resource	Alternative 1 (No Action)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Termination)	Alternative 4[1] (Reduced Production)
Water Quantity and Quality	The hatchery programs would have a low negative effect on water quantity, primarily because water use would generally be non-consumptive and limited by water right permits, and because all surface water diverted would be returned near the points of withdrawal after it circulates through the hatchery facilities.	Same as Alternative 1.	Effects on water quantity would be the same as Alternative 1, because although the proposed salmon and steelhead programs would be terminated, the operators would exercise their water rights for the hatchery facilities.	Although hatchery production would be reduced 50 percent, effects on water quantity would be the same as Alternative 1.
	The hatchery programs would have a negligible negative effect on water quality primarily because hatchery operations would are limited by NPDES permits and would not be expected to contribute substantially to water quality impairments in the basin.	Same as Alternative 1.	The hatchery programs would have a negligible positive effect on water quality because the proposed hatchery programs would be terminated.	Although hatchery production would be reduced 50 percent, effects on water quality would be the same as Alternative 1.
Salmon and Steelhead	The hatchery programs would generally have negligible to high negative genetics, competition, predation, facility operations, masking, incidental fishing, and disease transfer effects; and negligible to moderate positive population viability and nutrient cycling effects, depending on the affected species.	Same as Alternative 1.	Because the hatchery programs would be terminated, all negative and positive effects on salmon and steelhead from the programs would eliminated.	Because hatchery production would be reduced 50 percent, the negative genetics, competition, predation, facility operations, masking, incidental fishing, and disease transfer effects and the positive population viability and nutrient cycling effects, would be reduced compared to Alternative 1.

Table S-4. Summary of environmental consequences for EIS alternatives for each resource, continued.

Resource	Alternative 1 (No Action)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Termination)	Alternative 4[1] (Reduced Production)
Other Fish Species	The hatchery programs would have negligible negative or negligible positive effects on other fish species, depending on whether the hatchery-origin fish compete with or prey on the species.	Same as Alternative 1.	Because the hatchery programs would be terminated, all negative and positive effects on other fish species as competitors and predators would be eliminated.	Same as Alternative 1 because hatchery production would be reduced 50 percent and the negative effects on other fish species that compete with hatchery-origin fish, and the positive effects on other fish species that benefit from hatchery-origin fish as a food source would be reduced.
Wildlife – Southern Resident killer whale	The hatchery programs would have a negligible positive effect by providing a source of prey for Southern Resident killer whales.	Same as Alternative 1.	Because the hatchery programs would be terminated, there would be a negligible negative effect on Southern Resident killer whales because a source of prey would be eliminated.	Same as Alternative 1 because hatchery production would be reduced 50 percent and the positive effect on Southern Resident killer whales from hatchery-origin fish as source of prey would be reduced.
Socioeconomics	The hatchery programs would have a low positive effect on socioeconomics because personal income and jobs from tribal commercial and non-tribal recreational fisheries, income associated with hatchery operations, and contributions to the local and regional economies, would accrue primarily in King County in the South Puget Sound subregion. In addition, the economic activity and fisheries effects from the hatchery programs would have a relatively small impact on the overall economy of King County and in the broader Puget Sound region. In some of the more remote areas of the river basin and the South Puget Sound subregion more economically dependent on income derived the hatchery programs, effects would likely be greater.	Same as Alternative 1.	Because the hatchery programs would be terminated, there would be a low negative effect on socioeconomics because all commercial and recreational fishing, jobs, and personal income associated with the hatchery programs would be eliminated.	The hatchery programs would have a negligible positive effect on socioeconomics, because hatchery production would be reduced 50 percent resulting in fewer returning adults to be harvested in commercial and recreational fisheries, and contributions to regional and local economies would be less relative to Alternative 1.

Table S-4. Summary of environmental consequences for EIS alternatives for each resource, continued.

Resource	Alternative 1 (No Action)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Termination)	Alternative 4[1] (Reduced Production)
Environmental Justice	The hatchery programs would have a moderate positive effect on environmental justice, primarily because of their economic impact on communities of concern (King County and the South Puget Sound subregion) and benefits to Native American tribes of concern from fishing for ceremonial and subsistence and commercial purposes.	Same as Alternative 1.	Because the hatchery programs would be terminated, there would be a moderate negative effect on environmental justice because all commercial and recreational fishing in communities of concern associated with the hatchery programs would be eliminated. Tribal ceremonial and subsistence fishing would continue.	Same as Alternative 1 because, although hatchery production would be reduced 50 percent, the hatchery programs would substantially benefit fishing by user groups of concern (commercial fishermen) and Native American tribes of concern from fishing for ceremonial and subsistence and commercial purposes.
Human Health	The hatchery programs would have a negligible negative effect on human health, primarily because the hatchery programs comply with worker safety programs, rules, and regulations; the use of therapeutics would be minimal and in compliance with label requirements; and personal protective equipment would be used that limits the spread of pathogens.	Same as Alternative 1.	Because the hatchery programs would be terminated, the hatchery programs would have a negligible positive effect on human health.	Although hatchery production would be reduced 50 percent, human health effects would be the same as Alternative 1.

[1] Differences between the no-action and the action alternatives are due to differences in the number of hatchery-origin fish produced.

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Acronyms and Abbreviations

4(d) Rule	final rule pursuant to ESA section 4(d)
BMP	best management practice
BOD	biochemical oxygen demand
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
DAO	Departmental Administrative Order
DDT	dichlorodiphenyltrichloroethane
DGF	demographic gene flow
DNR	Washington Department of Natural Resources
DPS	distinct population segment
Ecology	Washington Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FRAM	Fishery Regulation and Assessment Model
FRF	fish restoration facility
FTE	full-time equivalent
HCP	habitat conservation plan
HGMP	hatchery and genetic management plan
HSRG	Hatchery Scientific Review Group
HxN	hatchery-origin cross natural-origin
ISAB	Independent Scientific Advisory Board

MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service (also called NOAA Fisheries Service)
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWIFC	Northwest Indian Fisheries Commission
NWFSC	Northwest Fisheries Science Center
PCB	polychlorinated biphenyl
PEHC	proportionate effective hatchery contribution
PEPD	Pending Evaluation and Proposed Determination
pHOS	proportion of hatchery-origin spawners
PNI	proportionate natural influence
pNOB	proportion of natural-origin fish in the hatchery broodstock
PRA	population recovery approach
PSP	Puget Sound Partnership
PSRC	Puget Sound Regional Council
RCO	Washington Recreation and Conservation Office
RCW	Revised Code of Washington
RM	river mile
RMP	resource management plan
ROD	Record of Decision
Services	USFWS and NMFS
SIWG	Species Interaction Work Group
TPU	Tacoma Public Utilities
USACE	U.S. Army Corps of Engineers

USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSP	viable salmonid population
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WRIA	water resource inventory area

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Glossary of Key Terms

4(d) Rule: A special regulation developed by NMFS under authority of section 4(d) of the ESA, modifying the normal protective regulations for a particular threatened species when it is determined that such a rule is necessary and advisable to provide for the conservation of that species.

Abundance: Generally, the number of fish in a defined area or unit. It is also one of four parameters used to describe the viability of natural-origin fish populations (McElhany et al. 2000).

Adaptive management: A deliberate process of using research, monitoring, and scientific evaluation when making decisions in the face of uncertainty.

Acclimation pond: A concrete or earthen pond or a temporary structure used for rearing and imprinting juvenile fish in the water of a particular stream before their release into that stream.

Anadromous: A term used to describe fish that hatch and rear in fresh water, migrate to the ocean to grow and mature, and return to fresh water to spawn.

Analysis area: Within this environmental impact statement (EIS), the analysis area is the geographic extent that is being evaluated for each resource. For some resources (e.g., socioeconomics and environmental justice), the analysis area is larger than the project area. See also **Project area**.

Best management practice (BMP): A policy, practice, procedure, or structure implemented to mitigate adverse environmental effects.

Biological opinion: Document stating the National Marine Fisheries Services' (NMFS') or the U.S. Fish and Wildlife Services' (USFWS') opinion as to how Federal agency actions affect ESA-listed species and critical habitat and whether a Federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat.

Broodstock: A group of sexually mature individuals of a species that is used for breeding purposes as the source for a subsequent generation.

Catch areas: Geographic areas defined by Washington State along the Pacific coast of Washington, Strait of Georgia, and Puget Sound that are used to report catch of fish and shellfish and determine specific regulations for fishing.

Ceremonial and subsistence: A phrase used to describe harvests by Puget Sound treaty tribes under their treaty-reserved fishing rights under *United States v. Washington*. Fish are used for tribal ceremonies and to meet the nutritional needs of tribal members.

Co-managers: Washington Department of Fish and Wildlife and Puget Sound treaty tribes, which are jointly responsible for managing fisheries and hatchery programs in the state of Washington.

Commercial harvest: The activity of catching fish for commercial profit.

Conservation: Used generally in this EIS as the act or instance of conserving or keeping fish resources from change, loss, or injury, and leading to their protection and preservation. This contrasts with the definition under the Federal Endangered Species Act (ESA), which refers to the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to the ESA are no longer necessary.

Critical habitat: A specific term and designation within the ESA referring to habitat area essential to the conservation of a listed species, though the area need not actually be occupied by the species at the time it is designated.

Density dependence: A term used in population ecology to describe how population growth rates are regulated by the density of a population. Usually, the denser a population is, the greater its mortality. Most density-dependent factors are biological in nature, such as predation and competition.

Dewatering: Typically, the immediate downstream habitat effects associated with a water withdrawal action that diverts the entire flow of a stream or river to another location.

Distinct population segment (DPS): Under the ESA, the term “species” includes any subspecies of fish or wildlife or plants, and any “distinct population segment” of any species or vertebrate fish or wildlife that interbreeds when mature. The ESA thus considers a DPS of vertebrates to be a “species.” The ESA does not however establish how distinctness should be determined. Under NMFS policy for Pacific salmon, a population or group of populations will be considered a DPS if it represents an evolutionarily significant unit (ESU) of the biological species. In contrast to salmon, NMFS lists steelhead runs under the joint NMFS-USFWS Policy for recognizing DPSs (DPS Policy: 61 Fed. Reg. 4722, February 7, 1996). This policy adopts criteria similar to those in the ESU policy, but applies to a broader range of animals to include all vertebrates. See also **Evolutionarily significant unit**.

Diversion: A facility, dam, or weir to direct water and fish for use at a hatchery facility. A diversion usually involves a screen to keep fish from entering a water intake. See also **Water intake**.

Diversity: Variation at the level of individual genes (polymorphism); provides a mechanism for populations to adapt to their ever-changing environment. It is also one of the four parameters used to describe the viability of natural-origin fish populations (McElhany et al. 2000).

Domestication: See **Hatchery-influenced selection**.

Endangered species: As defined under the ESA, any species that is in danger of extinction throughout all or a significant portion of its range.

Endangered Species Act (ESA): A United States law that provides for the conservation of endangered and threatened species of fish, wildlife, and plants.

Environmental justice: The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Escapement: Adult salmon and steelhead that survive fisheries and natural mortality and return to spawn.

Estuary: The area where fresh water of a river meets and mixes with the salt water of the ocean.

Evolutionarily significant unit (ESU): A concept NMFS uses to identify distinct population segments of Pacific salmon (but not steelhead) under the ESA. An ESU is a population or group of populations of Pacific salmon that 1) is substantially reproductively isolated from other populations, and 2) contributes substantially to the evolutionary legacy of the biological species. See also **Distinct Population Segment** (pertaining to steelhead).

Federal Register: The United States government's daily publication of Federal agency regulations and documents, including executive orders and documents that must be published per acts of Congress.

Fingerling: A juvenile fish.

Fishery: Harvest by a specific gear type in a specific geographical area during a specific time period.

Fishway: Any structure or modification to a natural or artificial structure to provide or enhance fish passage.

Fitness: As used in this EIS, the propensity of a group of fish (e.g., a population) to survive and reproduce.

Forage fish: Small fish that breed prolifically and serve as food for predatory fish.

Fry: Juvenile salmon and steelhead that are usually less than 1 year old and have absorbed their egg sac.

Gene flow: The genetic mechanism whereby genes are transferred from one population to another. See also **Introgression**.

Habitat: The physical, biological, and chemical characteristics of a specific unit of the environment occupied by a specific plant or animal; the place where an organism naturally lives.

Habitat conservation plan (HCP): A planning document required as part of an application for an incidental take permit for species listed under the ESA. An HCP describes the anticipated effects of the anticipated taking of a listed species resulting from otherwise lawful activities associated with a proposed action, how those impacts will be minimized or mitigated, and how the HCP is to be funded.

Hatchery and genetic management plan (HGMP): A technical document that describes the composition and operation of an individual hatchery program. Under Limit 5 of the 4(d) Rule, NMFS uses information in HGMPs to evaluate impacts on salmon and steelhead listed under the ESA. See also **Limit 5 and 6.**

Hatchery facility: A facility (e.g., hatchery, rearing pond, net pen) that supports one or more hatchery programs.

Hatchery-influenced selection: The process whereby genetic characteristics of hatchery populations become different from their source populations as a result of selection in hatchery environments (also referred to as domestication).

Hatchery operator: A Federal agency, state agency, or Native American tribe that operates a hatchery program.

Hatchery-origin fish: A fish that originated from a hatchery facility.

Hatchery-origin spawner: A hatchery-origin fish that spawns naturally.

Hatchery program: A program that artificially propagates fish. Most hatchery programs for salmon and steelhead spawn adults in captivity, raise the resulting progeny for a few months or longer, and then release the fish into the natural environment where they will mature.

Hatchery Scientific Review Group (HSRG): The independent scientific panel established and funded by Congress to provide an evaluation of hatchery reform in Puget Sound from 2000 to 2004.

Hydropower: Electrical power generation through use of gravitational force of falling water at dams.

Incidental: Unintentional, but not unexpected.

Incidental fishing effects: Fish, marine birds, or mammals unintentionally captured during fisheries using any of a variety of gear types.

Integrated hatchery program: A hatchery program that intends for the natural environment to drive the adaptation and fitness of a composite population of fish that spawns both in a hatchery and in the natural environment. Differences between hatchery-origin and natural-origin fish are minimized, and hatchery-origin fish are integrated with the local populations included in an ESU or DPS.

Introgression: Gene flow from non-local hatchery-origin salmon and steelhead into natural-origin populations.

Isolated hatchery program: A hatchery program that intends for the hatchery-origin population to be reproductively segregated from the natural-origin population. These programs produce fish that are different from local populations. They do not contribute to conservation or recovery of populations included in an ESU or DPS.

Limit 5 and 6: Under section 4(d) of the ESA (see **4(d) Rule**), Limit 5 is a limit on "take" prohibitions that identifies specific criteria for state and federal hatchery plans, and Limit 6 identifies criteria that apply to joint state/tribal resource management plans developed under the *United States v. Washington* (1974) or *United States v. Oregon* (1969) proceedings.

Limiting factor: A physical, chemical, or biological feature that impedes species and their independent populations from reaching a viable status.

National Environmental Policy Act (NEPA): A United States environmental law that established national policy promoting the enhancement of the environment and established the President's Council on Environmental Quality (CEQ).

National Marine Fisheries Service (NMFS): A United States agency within the National Oceanic and Atmospheric Administration and under the Department of Commerce charged with the stewardship of living marine resources through science-based conservation and management and the promotion of healthy ecosystems.

National Pollutant Discharge Elimination System (NPDES): A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency, a state, or, where delegated, a tribal government on an Indian reservation.

Native fish: Fish that are endemic to or limited to a specific region.

Natural-origin: A term used to describe fish that are offspring of parents that spawned in the natural environment rather than the hatchery environment, unless specifically explained otherwise in the text. "Naturally spawning" and similar terms refer to fish spawning in the natural environment.

Net pen: A fish rearing enclosure used in marine areas.

Northwest Indian Fisheries Commission (NWIFC): A support service organization to 20 treaty Indian tribes in western Washington, created following the *United States v. Washington* ruling, that assists member tribes in their role as natural resources co-managers.

Outmigration: The downstream migration of salmon and steelhead toward the ocean.

Pathogen: An infectious microorganism that can cause disease (e.g., virus, bacteria, fungus) in its host.

Population: A group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group.

Population recovery approach (PRA): A draft framework prepared by NMFS that categorizes listed Puget Sound Chinook salmon populations and the watersheds on which they depend into one of three tiers for ESA consultation and recovery planning purposes. Tier 1 populations are of primary importance for preservation, restoration, and ESU recovery and have to be viable for the ESU as a whole to meet viability criteria in the recovery plan for Puget Sound Chinook salmon. Tier 2 populations are less important for recovery to a low extinction risk status. Tier 3 populations are allowed to absorb more effects, but would still require ESA protection so that the populations maintain a trajectory toward recovery, albeit over a longer term than for Tier 1 and Tier 2 populations.

Preferred alternative: The alternative selected or developed from an evaluation of alternatives. Under NEPA, the preferred alternative is the alternative an agency believes would fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical, and other factors.

Productivity: The rate at which a population is able to produce reproductive offspring. It is one of the four parameters used to describe the viability of natural-origin fish populations (McElhany et al. 2000).

Project area: Geographic area where the Proposed Action would take place. See also **Proposed Action** and **Analysis area**.

Proportion of hatchery-origin spawners (pHOS): The proportion of naturally spawning salmon or steelhead that are hatchery-origin fish.

Proportionate natural influence (PNI): A measure of hatchery influence on natural populations that is a function of both the proportion of hatchery-origin spawners spawning in the natural environment (pHOS) and the proportion of natural-origin broodstock incorporated into the hatchery program (pNOB). PNI can also be thought of as the percentage of time all the genes of population collectively have spent in the natural environment.

Proposed Action: NMFS's review and approval under Limit 6 of the 4(d) Rule for 10 salmon and steelhead HGMPs (and hatchery releases) within the Duwamish-Green River Basin submitted as an RMP by the co-managers. See also **Limit 6** and **4(d) Rule**.

Puget Sound treaty tribes: Indian tribes in the project area with treaty fishing rights pursuant to *United States v. Washington*. For this EIS, the tribes are the Muckleshoot Indian Tribe and Suquamish Tribe.

Rearing pond: See **Acclimation Pond**.

Record of Decision (ROD): The formal NEPA decision document that is recorded for the public. It is announced in a Notice of Availability in the Federal Register.

Recovery: Defined in the ESA as the process by which the decline of an endangered or threatened species is stopped or reversed, or threats to its survival neutralized so that its long-term survival in the wild can be ensured and it can be removed from the list of threatened and endangered species.

Recovery plan: Under the ESA, a formal plan from NMFS (for listed salmon and steelhead) outlining the goals and objectives, management actions, likely costs, and estimated timeline to recover the listed species.

Recreational harvest: The activity of catching fish for non-commercial reasons (e.g., sport or recreation).

Redd: The spawning site or "nest" in stream and river gravels in which salmon and steelhead lay their eggs.

Residuals: Hatchery-origin fish that out-migrate slowly, if at all, after they are released. Residualism occurs when such fish residualize rather than out-migrate as most of their counterparts do.

Resource management plan (RMP): A plan that includes a process, management objectives, specific details, and other information required to manage a natural resource. For this EIS, the resources are salmon and steelhead hatchery programs in the Duwamish-Green River Basin.

River basin: The area drained by a river and its tributaries.

Run: The migration of salmon or steelhead from the ocean to fresh water to spawn. Defined by the season they return as adults to the mouths of the rivers from which they originated.

Run size: The number of adult salmon or steelhead (i.e., harvest plus escapement) returning to the rivers from which they originated. See also **Total Return**.

Scoping: In NEPA, an early and open process for determining the extent and variety of issues to be addressed and for identifying the significant issues related to a proposed action (40 CFR 1501.7).

Section 7 consultation: Federal agency consultation with NMFS or USFWS (dependent on agency jurisdiction) on any actions that may affect listed species, as required under section 7 of the ESA.

Section 10 permit: A permit for direct take of listed species for scientific purposes or to enhance the propagation or survival of listed species. Issued by NMFS or USFWS (dependent on agency jurisdiction) as authorized under section 10(a)(1)(A) of the ESA.

Smolts: Juvenile salmon and steelhead that have left the streams from which they originated, are out-migrating downstream, and are physiologically adapting to live in salt water.

Smoltification: The process of physiological change that juvenile salmon and steelhead undergo in fresh water while out-migrating to salt water that allow them to live in the ocean.

Spatial structure: The spatial structure of a population refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. It is one of the four parameters used to describe the viability of natural-origin fish populations (McElhany et al. 2000).

Stock: A group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place in a different season.

Straying (of hatchery-origin fish): A term used to describe when hatchery-origin fish return to and/or spawn in areas where they are not intended to return/spawn.

Subyearling: Juvenile salmon less than 1 year of age.

Supplementation: Release of fish into the natural environment to increase the abundance of naturally reproducing fish populations.

Take: Under the ESA, the term "take" means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Take for hatchery activities includes, for example, the collection of listed fish (adults and juveniles) for hatchery broodstock, the collection of listed hatchery-origin fish to prevent them from spawning naturally, and the collection of listed fish (juvenile and adult fish) for scientific purposes.

Threat: A human action or natural event that causes or contributes to limiting factors; threats may be caused by past, present, or future actions or events. See also **Limiting factor**.

Threatened species: As defined by section 4 of the ESA, any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Total return: The number of adult salmon or steelhead (i.e., harvest plus escapement) returning to the streams from which they originated. See also **Run size**.

Tributary: A stream or river that flows into a larger stream or river.

Viability: As used in this EIS, a measure of the status of listed salmon and steelhead populations that uses four criteria: abundance, productivity, spatial distribution, and diversity.

Viable salmonid population (VSP): An independent population of salmon or steelhead that has a negligible risk of extinction over a 100-year timeframe (McElhany et al. 2000).

Volitional: A term used to describe the method of passively releasing fish that allows fish to leave hatchery facilities when the fish are ready.

Water right: A legal authorization to divert or withdraw some portion of the public waters of the state (surface water or ground water) for a beneficial purpose, subject to the specific terms and conditions of a water right permit, certificate, or claim. A certificate is issued by Washington State as the official legal record of the water right when it has confirmed that the water has been put to beneficial use according to terms and conditions of the permit. Once a water right has been put to beneficial use, the water must continue to be used or the holder will face possible loss of all or a portion of the right through abandonment or relinquishment.

Water intake: Structure used to access water from a stream for use at hatchery facilities. A water intake usually involves some form of screen to prevent salmon and steelhead from entering the intake. See also **Diversion.**

Watershed: An area of land or catchment where all of the water that is under it or drains off of it goes into the same place.

Weir: An adjustable dam placed across a river to regulate the flow of water downstream; a fence placed across a river to catch fish.

Water resource inventory area (WRIA): A system for delineating watersheds used by Washington State.

Yearling: Juvenile salmon or steelhead that has reared at least 1 year in a hatchery.

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Chapter 1

1 PURPOSE OF AND NEED FOR THE PROPOSED ACTION

1.1 Background

1.1.1 Administering the Endangered Species Act

The National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) is the lead agency responsible for administering the Federal Endangered Species Act (ESA) as it relates to listed salmon and steelhead. Actions that may affect listed species are reviewed by NMFS under section 7 or section 10 of the ESA or under section 4(d), which can be used to limit the application of take prohibitions described in section 9. On June 19, 2000, NMFS issued a final rule pursuant to ESA section 4(d) (4(d) Rule), adopting regulations necessary and advisable to conserve threatened species (50 Code of Federal Regulations [CFR] 223.203). The 4(d) Rule applies the take prohibitions in section 9(a)(1) of the ESA to salmon and steelhead listed as threatened, and also sets forth specific circumstances when the prohibitions will not apply, known as 4(d) limits. With regard to hatchery programs (Box 1-1) that meet the substantive requirements for hatchery and genetic management plans (HGMPs) described under Limit 5 of the 4(d) Rule, and where such hatchery programs are jointly submitted by tribal and state governments and meet the substantive requirements for hatchery or fishery resource management plans (RMPs) under Limit 6[1] of the 4(d) Rule, NMFS declared that section 9 take prohibitions would not apply (Subsection 1.5.3, NMFS' Determination as to Compliance with the 4(d) Rule).

[1] The 4(d) Rule prohibits the take of listed threatened salmon or steelhead, except in cases where the take is associated with an approved program. The 4(d) Rule includes a set of 13 limits (including Limit 5 and Limit 6 regarding hatcheries) on the application of ESA take prohibitions for specific categories of activities that adequately limit the adverse impacts of those activities. Limit 5 identifies specific criteria for state and federal HGMPs, whereas Limit 6 identifies criteria for joint tribal/state RMPs developed under the *United States v. Washington* (1974) or *United States v. Oregon* (1969) court proceedings.

Box 1-1. What are hatchery and genetic management plans and hatchery resource management plans? What are the differences between hatchery programs and hatchery facilities?

Hatchery and Genetic Management Plans – Hatchery and genetic management plans, or HGMPs, are specific to the ESA and are outlined under Limit 5 of the 4(d) Rule. They are the plans that describe hatchery programs and reflect the fish species propagated, the main hatchery facility used, the life stage when the fish are released, and the location of fish releases. In general, several hatchery programs and their associated HGMPs may be associated with each primary hatchery facility. For example, the Soos Creek Hatchery facilities support fall-run Chinook salmon, summer-run steelhead, and coho salmon programs described in three HGMPs (Table 1 and Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities).

Resource Management Plans – Resource management plans, or RMPs, are also specific to the ESA and are outlined under Limit 6 of the 4(d) Rule. They can pertain to fishery management plans or hatchery management plans. HGMPs can serve as RMPs for hatchery programs. RMPs are jointly prepared by the Washington Department of Fish and Wildlife (WDFW) and Puget Sound treaty tribes under *United States v. Washington* (1974) court proceedings. The plans may encompass tribal, state, and Federal hatchery programs and facilities, which often operate in the same watersheds, exchange eggs, and share rearing space to maximize effectiveness.

Hatchery Programs and Facilities – Hatchery programs are defined by how the artificial production for individual species at facilities are managed and operated. Hatchery facilities are defined by the physical structures required for artificial production (e.g., hatchery buildings, adult holding or juvenile rearing ponds).

1.1.2 Hatchery and Genetic Management Plan Submittal

The Washington Department of Fish and Wildlife (WDFW), Muckleshoot Indian Tribe, and Suquamish Tribe, as co-managers of the fisheries resource under *United States v. Washington*, 384 F. Supp. 312 (W.D. Wash 1974) (hereafter referred to as "the co-managers") (Box 1-2), have provided NMFS with 10 HGMPs describing 10 hatchery programs for fall-run Chinook salmon, late winter-run steelhead, summer-run steelhead, coho salmon, fall-run chum salmon, and associated monitoring and evaluation actions in the Duwamish-Green River Basin that affect ESA-listed Puget Sound Chinook salmon and Puget Sound steelhead (Table 1) (James B. Scott, WDFW, letter sent to Robert Turner, Assistant Regional Administrator, NMFS, April 3, 2013, regarding the Soos Creek fall-run Chinook salmon HGMP; Kelly Cunningham, WDFW, letter sent to Robert Turner, Assistant Regional Administrator, NMFS, July 28 2014, regarding the Soos Creek coho salmon HGMP; Kelly Cunningham, WDFW, letter sent to Robert Turner, Assistant Regional Administrator, NMFS, November 17, 2014, regarding the Green River late winter-run steelhead and Marine Technology Center coho salmon HGMP; Kelly Cunningham, WDFW, letter sent to Robert Turner, Assistant Regional Administrator, NMFS, December 14, 2015, regarding the Soos Creek early summer-run steelhead HGMP; Isabel Tinoco, Muckleshoot Indian Tribe, email sent to Tim Tynan, Fish Biologist, NMFS, December 17, 2014, regarding seven HGMPs; Isabel Tinoco, Muckleshoot Indian Tribe, email sent to Tim Tynan, Fish Biologist, NMFS, December 17, 2014, regarding the Keta Creek coho salmon HGMP). The HGMPs provide the frameworks through which the Washington State and tribal jurisdictions propose to jointly and adaptively manage hatchery operations, monitoring, and evaluation activities, while meeting requirements specified under the ESA.

Box 1-2. What is *United States v. Washington*, and what does it do?

United States v. Washington is the 1974 Federal court proceeding that enforces and implements treaty fishing rights for salmon and steelhead (and other species) returning to Puget Sound (and other areas). Fishing rights and access to fishing areas in Puget Sound were reserved in treaties that the Federal government signed with the tribes in the 1850s. Under *United States v. Washington*, the Puget Sound Salmon Management Plan is the implementation framework for the allocation, conservation, and equitable sharing principles defined in *United States v. Washington* that governs the joint management of harvest of salmon and steelhead resources between the Puget Sound treaty tribes and State of Washington. The joint hatchery RMP reviewed in this environmental impact statement (EIS), and joint harvest RMPs such as the Puget Sound Chinook harvest management plan, are components of the Puget Sound Salmon Management Plan.

Table 1. HGMPs describing 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin.

Hatchery Program	Primary Facilities	Operator	HGMP Last Updated
Soos Creek fall-run Chinook salmon[1]	Soos Creek Hatchery Icy Creek Pond Palmer Pond	WDFW	April 3, 2013
Fish restoration facility (FRF) fall-run Chinook salmon[1]	FRF	Muckleshoot Indian Tribe	July 29, 2014
Green River late winter-run steelhead[1]	Soos Creek Hatchery Icy Creek Pond Flaming Geyser Pond Palmer Pond	WDFW	October 13, 2014
FRF late winter-run steelhead[1]	FRF	Muckleshoot Indian Tribe	July 18, 2014
Soos Creek summer-run steelhead	Soos Creek Hatchery Icy Creek Pond	WDFW	October 30, 2015
Soos Creek coho salmon	Soos Creek Hatchery Miller Creek Hatchery Des Moines Marina Net Pens	WDFW	May 10, 2014
Keta Creek coho salmon	Soos Creek Hatchery (a source of subyearlings) Keta Creek Complex Elliott Bay Net Pens	Muckleshoot Indian Tribe and Suquamish Tribe	June 22, 2017
Marine Technology Center coho salmon	Marine Technology Center Soos Creek Hatchery (a source of eggs)	WDFW	September 17, 2014
FRF coho salmon	FRF	Muckleshoot Indian Tribe	July 21, 2014
Keta Creek chum salmon	Keta Creek Complex	Muckleshoot Indian Tribe	July 18, 2014

Sources: Muckleshoot Indian Tribe 2014a, 2014b, 2014c, 2014d; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014b, 2014c, 2015

[1] Hatchery-origin fish produced by the program are listed as threatened under the ESA.

The co-managers developed the plans jointly, and have provided the HGMPs for review and determination by NMFS as to whether they address the criteria under Limit 6 of the 4(d) Rule, using the specific criteria for hatchery programs under Limit 5 of the 4(d) Rule. For the purposes of the proposed recommendation, NMFS considers the 10 joint HGMPs, submitted for consideration under Limit 6, to be an RMP. For more information on the 4(d) Rule, see Subsection 1.5.3, NMFS' Determination as to Compliance with the 4(d) Rule.

1.1.3 Related National Environmental Policy Act Reviews

NMFS conducted a previous National Environmental Policy Act (NEPA) analysis relevant to this environmental impact statement (EIS), specifically, a draft EIS reviewing two RMPs and appended HGMPs for Puget Sound salmon and steelhead hatcheries (i.e., Draft Environmental Impact Statement on Two Joint State and Tribal Resource Management Plans for Puget Sound Salmon and Steelhead Hatchery Programs – herein referred to as the PS Hatcheries DEIS [NMFS 2014a]) (79 Fed. Reg. 43465, July 25, 2014), subsequently terminated (80 Fed. Reg. 15986, March 26, 2015). As discussed in the Federal Register Notice terminating the preparation of a single EIS and review under the 4(d) Rule of two RMPs and appended HGMPs for hatchery programs in the Puget Sound Basin, NMFS determined that, following the public comment period on the PS Hatcheries DEIS (NMFS 2014a), reviews under NEPA and the 4(d) Rule organized around smaller numbers of HGMPs would allow for more detailed analyses of potential effects of individual HGMPs than the scope of review in the PS Hatcheries DEIS (NMFS 2014a). Additionally, analyses of all hatchery programs in the Puget Sound Basin under one NEPA review is not necessary to fully consider effects of those programs. Although currently over 100 salmon and steelhead hatchery programs operate in the Puget Sound Basin (Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities), they have different operators (e.g., state and tribal), they do not rely on each other for their operation or justification, and updated HGMPs/RMPs for these programs either have recently been or are expected to be submitted by the co-managers to NMFS for approval, generally on a watershed-specific basis. The combined effects of all hatchery programs within the Puget Sound Basin are addressed in this EIS in Chapter 5, Cumulative Effects.

The 10 HGMPs grouped into this EIS review were organized in this way because all 10 hatchery programs pertain to salmon and steelhead hatchery programs that occur in the Duwamish-Green River Basin and would affect similar resources.

This EIS incorporates information by reference from the PS Hatcheries DEIS (NMFS 2014a), including detailed discussions on the ESA (PS Hatcheries DEIS, Subsection 1.1.1, The Endangered Species Act), take of listed species with specific information related to Puget Sound Hatchery RMPs and HGMPs, and background on the use of hatcheries in Puget Sound (PS Hatcheries DEIS, Subsection 1.1.2, Take of a Listed Species). Information incorporated by reference from the PS Hatcheries DEIS (NMFS 2014a) is summarized within various subsections of this EIS.

1.2 Description of the Proposed Action

Under the Proposed Action, NMFS would determine whether the HGMPs submitted as an RMP meet the requirements of Limit 6 of the 4(d) Rule. Activities included in the HGMPs generally are as follows:

- Broodstock collection through operation of weirs, fish traps, and adult collection ponds (Table 2)
- Holding, identification, and spawning of adult fish at Soos Creek Hatchery, Keta Creek Complex, Marine Technology Center, Icy Creek Pond, and at a new fish restoration facility (FRF) (Table 2)
- Egg incubation at Soos Creek Hatchery, Keta Creek Hatchery, Marine Technology Center, Icy Creek Pond, and at a new FRF (Table 2)
- Fish rearing at Soos Creek Hatchery, Icy Creek Pond, Palmer Pond, a potential rearing facility at Green River (river mile [RM] 60, Miller Creek Hatchery, Des Moines Net Pens, Elliott Bay Net Pens, Keta Creek Complex, Marine Technology Center, and Flaming Geyser Pond (Table 2)
- Release of fall-run Chinook salmon, steelhead, coho salmon, and chum salmon into the Duwamish-Green River Basin (Table 2)
- Removal of adult hatchery-origin salmon and steelhead returning to the Duwamish-Green River Basin at weirs, fish traps, and other collection facilities
- Monitoring and evaluation activities to assess the performance of the hatchery programs in meeting conservation, harvest augmentation, and listed fish risk minimization objectives (Table 2)

Table 2. Hatchery facilities, locations, and activities associated with 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin. All programs use facilities that exist under current conditions and are operated under current conditions, except for the three FRF hatchery programs.

Hatchery Program	Facility	Location	Broodstock Collection	Spawning Facilities	Incubation Facilities	Rearing Facilities	Juvenile Fish Release	Monitoring and Evaluation
Soos Creek fall-run Chinook salmon	Soos Creek Hatchery	Big Soos Creek (water resource inventory area [WRIA] 09.0072) at RM 0.6, tributary to the Green River (WRIA 09.0001) at RM 33.6	✓	✓	✓	✓	✓	✓
	Icy Creek Pond	Icy Creek (WRIA 09.0125), tributary to the Green River (WRIA 09.0001) at RM 48.3				✓	✓	✓
	Palmer Pond	Unnamed stream (WRIA 09.0147) at RM 0.2, tributary to the Green River (WRIA 09.0001) at RM 56.1				✓	✓	✓
	Tacoma Water Headworks	Green River (WRIA 09.0001) at RM 61	✓					✓
FRF fall-run Chinook salmon	Soos Creek Hatchery	Big Soos Creek (WRIA 09.0072) at RM 0.6, tributary to the Green River (WRIA 09.0001) at RM 33.6	✓				✓	✓
	Palmer Pond	Unnamed stream (WRIA 09.0147) at RM 0.2, tributary to the Green River (WRIA 09.0001) at RM 56.1	✓					✓
	FRF	Green River (WRIA 09.0001) at RM 60	✓	✓	TBD	TBD	✓	✓
	NA	Various streams in upper Green River watershed upstream of Howard Hanson Dam (Green River [WRIA 09.0001] at RM 64) and/or in various streams in the area: Sunday, Snow, Smay, McCain, Friday, Intake, Tacoma, Canton, Gale, and Charley Creeks; North Fork Green River; and the Green River mainstem					✓	✓
	Tacoma Water Headworks	Green River (WRIA 09.0001) at RM 61	✓			✓		✓

Table 2. Hatchery facilities, locations, and activities associated with 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin. All programs use facilities that exist under current conditions and are operated under current conditions, except for the three FRF hatchery programs, continued.

Hatchery Program	Facility	Location	Broodstock Collection	Spawning Facilities	Incubation Facilities	Rearing Facilities	Juvenile Fish Release	Monitoring and Evaluation
Green River late winter-run steelhead	Soos Creek Hatchery	Big Soos Creek (WRIA 09.0072) at RM 0.6, tributary to the Green River (WRIA 09.0001) at RM 33.6	✓	✓	✓			✓
	Icy Creek Pond	Icy Creek (WRIA 09.0125) tributary to the Green River (WRIA 09.0001) at RM 48.3	✓			✓	✓	✓
	Flaming Geyser Pond	Cristy Creek (WRIA 09.0038) at RM 0.1, tributary to the Green River (WRIA 09.0001) at RM 44.3				✓	✓	✓
FRF late winter-run steelhead	FRF	Green River (WRIA 09.0001) at RM 60	✓	✓	TBD	TBD	✓	✓
	Tacoma Water Headworks	Green River (WRIA 09.0001) at RM 61	✓					✓
	NA	Various streams in upper Green River watershed upstream of Howard Hanson Dam (Green River [WRIA 09.0001] at RM 64) and/or in various streams in the area: Sunday, Snow, Smay, McCain, Friday, Intake, Tacoma, Canton, Gale, and Charley Creeks; North Fork Green River; and the Green River mainstem					✓	✓
Soos Creek summer-run steelhead	Soos Creek Hatchery	Big Soos Creek (WRIA 09.0072) at RM 0.6, tributary to the Green River (WRIA 09.0001) at RM 33.6	✓	✓	✓	✓	✓	✓
	Icy Creek Pond	Icy Creek (WRIA 09.0125), tributary to the Green River (WRIA 09.0001) at RM 48.3				✓	✓	✓
Soos Creek coho salmon	Soos Creek Hatchery	Big Soos Creek (WRIA 09.0072) at RM 0.6, tributary to the Green River (WRIA 09.0001) at RM 33.6	✓	✓	✓	✓	✓	✓
	Miller Creek Hatchery	Miller Creek (WRIA 09.0371) at approximately RM 1, on the grounds of the Southwest Suburban Sewer District Miller Creek Plant				✓	✓	✓

Table 2. Hatchery facilities, locations, and activities associated with 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin. All programs use facilities that exist under current conditions and are operated under current conditions, except for the three FRF hatchery programs, continued.

Hatchery Program	Facility	Location	Broodstock Collection	Spawning Facilities	Incubation Facilities	Rearing Facilities	Juvenile Fish Release	Monitoring and Evaluation
	Des Moines Net Pens	Des Moines Marina (WRIA 09.0377)				✓	✓	✓
	Des Moines Net Pens	Des Moines Creek (WRIA 09.0377) near Des Moines Marina					✓	
Keta Creek coho salmon	Soos Creek Hatchery	Big Soos Creek (WRIA 09.0072) at RM 0.6, tributary to the Green River (WRIA 09.0001) at RM 33.6	✓					✓
Keta Creek coho salmon	Keta Creek Complex	Crisp Creek (WRIA 09.0013) at RM 1.1, tributary to the Green River (WRIA 09.0001) entering at RM 40.1	✓	✓	✓	✓	✓	✓
Keta Creek coho salmon	Tacoma Water Headworks	Green River (WRIA 09.0001) at RM 61	✓				✓	✓
Keta Creek coho salmon	NA	Green River (09.0001) at RM 60.5					✓	✓
Keta Creek coho salmon	Elliott Bay Net Pens	Elliott Bay, near Pier 70 at Seattle waterfront (WRIA 9.0072)					✓	
Marine Technology Center coho salmon	Marine Technology Center	Seahurst Park, Burien	✓	✓	✓	✓	✓	✓
Marine Technology Center coho salmon	Soos Creek Hatchery	Big Soos Creek (WRIA 09.0072) at RM 0.6, tributary to the Green River (WRIA 09.0001) at RM 33.6	✓					✓
FRF coho salmon	FRF	Green River (WRIA 09.0001) at RM 60	✓	✓	TBD	TBD	✓	✓
FRF coho salmon	Tacoma Water Headworks	Green River (WRIA 09.0001) at RM 61	✓					✓
FRF coho salmon	NA	Various streams in upper Green River watershed upstream of Howard Hanson Dam (Green River [WRIA 09.0001] at RM 64) and/or in various streams in the area: Sunday, Snow, Smay, McCain, Friday, Intake, Tacoma, Canton, Gale, and Charley Creeks; North Fork Green River; and the Green River mainstem					✓	✓

Table 2. Hatchery facilities, locations, and activities associated with 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin. All programs use facilities that exist under current conditions and are operated under current conditions, except for the three FRF hatchery programs, continued.

Hatchery Program	Facility	Location	Broodstock Collection	Spawning Facilities	Incubation Facilities	Rearing Facilities	Juvenile Fish Release	Monitoring and Evaluation
Keta Creek chum salmon	Keta Creek Complex	Crisp Creek (WRIA 09.0013) at RM 1.1, tributary to the Green River (WRIA 09.0001) at RM 40.1	✓	✓	✓	✓	✓	✓
	Duwamish-Green River Basin areas accessible to natural-origin salmon and steelhead migration, spawning, and rearing	Duwamish-Green River Basin areas, including tributaries, extending from Elliott Bay and river mouths to the upstream extent of anadromous fish access.						✓

Sources: Muckleshoot Indian Tribe 2014a, 2014b, 2014c, 2014d; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014b, 2014c, 2015

NA: Not applicable.

RM: River mile, measured from the farthest downstream point on the stream in question.

TBD: To be determined.

WRIA: Water resources inventory area, typically defining a geographic area where surface water runoff drains into a common surface water body, such as a lake, section of stream, or bay.

Maximum annual releases of juvenile fish under the Proposed Action for each hatchery program that are analyzed in this EIS are shown in Table 3 below.

The proposed FRF would be funded by the City of Tacoma through its Department of Public Utilities (TPU) and operated by the Muckleshoot Indian Tribe under the 1995 Settlement Agreement between the Muckleshoot Indian Tribe and the City of Tacoma regarding the municipal water supply operations in the Duwamish-Green River Basin. The proposed FRF would support three HGMPs that would rear and release juvenile fall-run Chinook salmon, steelhead, and coho salmon into the Green River watershed. Under the Settlement Agreement, TPU in consultation with the Muckleshoot Indian Tribe, would fund the design, engineering, environmental review, permitting, construction, and regulatory review and approval of the FRF. No dates have been established for construction and implementation of the FRF. The proposed FRF for fall-run Chinook salmon, steelhead, and coho salmon hatchery programs would be constructed near Green River RM 60. The locations and life stages of fish released would depend on whether downstream passage facilities for juveniles are provided at the U.S. Army Corps of Engineers (USACE) Howard Hanson Dam near RM 64. If downstream fish passage is not available at Howard Hanson Dam, all fish releases from the three programs would occur below the dam (fall-run Chinook salmon subyearlings and coho salmon and steelhead yearlings). If downstream fish passage is available, most fish would be distributed into release areas in the upper watershed above the dam (Table 3). This EIS evaluates environmental effects of both scenarios (with and without downstream fish passage) for the three hatchery programs associated with the FRF.

Table 3. Maximum annual releases from 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin.

Hatchery Program	Program Type[1]	Maximum Annual Release Level
Soos Creek fall-run Chinook salmon	Integrated harvest	4,200,000 subyearlings 300,000 yearlings
FRF fall-run Chinook salmon	Integrated harvest	600,000 If no downstream passage: all would be released as subyearlings below Howard Hanson Dam If downstream passage: 100,000 would be released as subyearlings below Howard Hanson Dam, and 500,000 released as fry above the dam
Green River late winter-run steelhead	Integrated conservation	33,000 yearlings
FRF late winter-run steelhead	Integrated harvest	350,000 If no downstream passage: all would be released as yearlings below Howard Hanson Dam If downstream passage: 70,000 would be released as yearlings below Howard Hanson Dam, and 280,000 released as fry above the dam
Soos Creek summer-run steelhead	Isolated harvest	100,000 yearlings
Soos Creek coho salmon	Integrated harvest	630,000 yearlings 120,000 fry
Keta Creek coho salmon	Integrated harvest	2,050,000 yearlings
Marine Technology Center coho salmon	Isolated harvest/education	10,000 yearlings

Table 3. Maximum annual releases from 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin, continued.

Hatchery Program	Program Type[1]	Maximum Annual Release Level
FRF coho salmon	Integrated harvest	600,000 If no downstream passage: all would be released as yearlings below Howard Hanson Dam If downstream passage: 100,000 would be released as yearlings below Howard Hanson Dam, and 500,000 released as fry above the dam
Keta Creek chum salmon	Integrated harvest	5,000,000 fry

Sources: Muckleshoot Indian Tribe 2014a, 2014b, 2014c, 2014d; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014b, 2014c, 2015

[1] Program type:

Integrated: a hatchery program with harvest and/or conservation and recovery management objectives that intends for the natural environment to drive the adaptation and fitness of a composite population of fish that spawns in both a hatchery and in the natural environment. Differences between hatchery-origin and natural-origin fish are minimized, and hatchery-origin fish are integrated with the local populations included in an evolutionarily significant unit (ESU) or distinct population segment (DPS) and can contribute to conservation or recovery of listed species.

Isolated: a hatchery program that intends for the hatchery-origin population to be reproductively segregated from the natural-origin population. These programs produce fish that are different from local populations. They do not contribute to conservation or recovery of populations included in an ESU or DPS.

For the proposed FRF and the existing three Soos Creek Hatchery programs, this EIS evaluates the environmental effects of implementing the HGMPs as proposed. Additional proposed improvements or changes to facilities or programs may require supplemental analysis if and when those improvements or changes are proposed. In addition, this EIS does not evaluate impacts that might be associated with the future construction of facilities for the proposed FRF hatchery programs, as that construction is not part of the proposed action.

As described in Subsection 1.5.3, NMFS' Determination as to Compliance with the 4(d) Rule, NMFS would require monitoring and evaluation as a condition of its approvals under the 4(d) Rule. Monitoring and evaluation under approved HGMPs would address the performance of the hatchery programs in meeting and adaptively managing their objectives. Monitoring activities (Table 2) would include, but not be limited to, obtaining information on smolt-to-adult survival, fishery contribution, natural-origin and hatchery-origin spawning abundance, juvenile out-migrant abundance and diversity, genetics, and juvenile and adult fish health when the fish are in hatchery facilities.

1.3 Purpose of and Need for the Proposed Action

This EIS identifies the purpose and need for the NMFS action and objectives of the state and tribal fisheries co-managers.

The purpose of the Proposed Action from NMFS' perspective is to evaluate the submitted HGMPs for ESA compliance. The need for the Proposed Action is to ensure the sustainability and recovery of Puget Sound salmon and steelhead by conserving the productivity, abundance, diversity, and distribution of listed species of salmon and steelhead in Puget Sound. NMFS will ensure it meets its tribal trust stewardship responsibilities and will also work collaboratively with the Muckleshoot Indian Tribe, Suquamish Tribe, and WDFW to protect and conserve listed species.

The co-managers' objectives in developing and submitting the 10 HGMPs for salmon and steelhead hatchery programs in the Duwamish-Green River Basin as an RMP under Limit 6 of the 4(d) Rule are to operate their hatcheries to meet resource management and protection goals with the assurance that any harm, death, or injury to fish within a listed evolutionarily significant unit (ESU) or distinct population segment (DPS) does not appreciably reduce the likelihood of a species' survival and recovery and is not in the category of prohibited take under the 4(d) Rule.

The co-managers also have as an objective the continued operation of salmon and steelhead hatchery programs using existing facilities for conservation, mitigation, and tribal and non-tribal fishing opportunity pursuant to the Puget Sound Salmon Management Plan implemented under *United States v. Washington*, and treaty rights preservation purposes while meeting ESA requirements.

WDFW and the Puget Sound treaty tribes strive to protect, restore, and enhance the productivity, abundance, and diversity of Puget Sound salmon and steelhead and their ecosystems to sustain treaty ceremonial and subsistence fisheries, treaty and non-treaty commercial and recreational fisheries, non-consumptive fish benefits, and other cultural and ecological values.

As described in Box 1-3, NMFS has an obligation to administer the provisions of the ESA and to protect listed salmon and steelhead, and also has a Federal trust responsibility to treaty Indian tribes. Thus, NMFS seeks to harmonize the reduction in the negative effects of hatchery programs with the provision of hatchery-origin fish for tribal harvest and for conservation purposes.

Box 1-3. How does NMFS harmonize its conservation mandate under the ESA with stewardship of treaty Indian fishing rights?

In addition to the biological requirements for conservation under the ESA, NMFS has a Federal trust responsibility to treaty Indian tribes. In recognition of its treaty rights stewardship obligation and consistent with Secretarial Order 3206 (see Subsection 1.7.7, Secretarial Order 3206), NMFS, as a matter of policy, will make every effort to harmonize the protection of listed species and the provision for tribal fishing opportunity. NMFS recognizes that the treaty tribes have a right to conduct their fisheries within the limits of conservation constraints. Because of the Federal government's trust responsibility to the tribes, NMFS is committed to considering the tribal co-managers' judgment and expertise regarding conservation of trust resources. Limit 6 of the 4(d) Rule explicitly requires this.

This EIS does not document whether specific actions of hatchery programs meet the requirements of Limit 6 of the 4(d) Rule under the ESA. Those ESA decisions will be made in separate processes consistent with applicable regulations as required by the ESA (Subsection 1.5.3, NMFS' Determination as to Compliance with the 4(d) Rule).

1.4 Project and Analysis Areas

The project area is the geographic area where the Proposed Action would take place (Figure 1). It includes the places where the proposed salmon and steelhead hatchery programs would (1) collect broodstock; (2) spawn, incubate, and rear fish; (3) release fish; or (4) remove surplus hatchery-origin adult salmon and steelhead that return to hatchery facilities; and (5) conduct monitoring and evaluation activities. The project area consists of the Duwamish-Green River Basin, as well as the following primary hatchery and satellite facilities and their immediate surroundings:

- Soos Creek Hatchery
- Icy Creek Pond
- Palmer Pond
- Miller Creek Hatchery
- Tacoma Water Headworks Diversion Fish Trap
- FRF (facilities to be constructed)
- Flaming Geyser Pond

- Elliott Bay Net Pens
- Marine Technology Center
- Des Moines Net Pens
- Keta Creek Complex

Figure 1. Project area and locations of primary hatchery facilities. Taken from WDFW (2014a).

The river basin is 93 miles long, covers nearly 500 square miles, and is located entirely within King County. The upper watershed is mostly forested, while the lower watershed is urban and industrial. While the Green River provides 83 miles of freshwater habitat, the Duwamish River in the lower basin provides a 6-mile zone where fresh and salt water mix. Major tributaries of the basin include the Black River, Springbrook Creek, Mill Creek, Soos Creek, Jenkins Creek, Covington Creek, Newaukum Creek, and Crisp Creek. Along the marine shoreline, smaller streams drain directly to Puget Sound.

The upper watershed also supports the City of Tacoma's municipal water source and diversion dam, which was built in 1911 (at RM 61), and also supports the USACE Howard Hanson Dam (RM 64) which was completed in 1962. Howard Hanson Dam blocks fish passage to over 45 percent of the upper Green River watershed. Although the dams were built without fish passage facilities, fish passage improvements have occurred and more are planned. The Green and Duwamish Rivers were historically separate rivers; however, in 1909, modifications to the Duwamish and Green Rivers resulted in the two rivers joining as one watershed.

The analysis area is the geographic extent that is being evaluated for a particular resource. For some resources, the analysis area may be larger than the project area, since some of the effects of the alternatives may occur outside the project area. The analysis area is described at the beginning of Chapter 3, Affected Environment, for each resource.

1.5 Decisions to be Made

NMFS must decide on the following before the Proposed Action can be implemented:

- The preferred alternative, following an analysis of all alternatives in this EIS and review of public comment on the EIS
- Whether the Proposed Action complies with ESA criteria under the 4(d) Rule

1.5.1 Preferred Alternative to be Identified in the Final EIS

A preferred alternative is not identified in this draft EIS; it will be identified in the final EIS. The preferred alternative for all programs could be the Proposed Action, or it could be a combination of components of the alternatives evaluated in the draft EIS. Information from the public review process will be used in selecting a preferred alternative.

1.5.2 Record of Decision

This NEPA process will culminate in a Record of Decision (ROD) that will record NMFS' selected alternative. The ROD will identify all of the alternatives considered by NMFS; identify the environmentally preferable alternative; describe the preferred alternative and the selected alternative; and summarize the impacts expected to result from implementation of the selected alternative. Similar to the preferred alternative in the final EIS, the selected alternative in the ROD could be the preferred alternative or could be a combination of components of alternatives evaluated in the final EIS. The ROD will also consider comments on the final EIS. The ROD will be completed after public review and comment on the final EIS, and after the ESA determinations and associated public review processes are completed.

1.5.3 NMFS' Determination as to Compliance with the 4(d) Rule

Discussions between the co-managers and NMFS during development of hatchery RMPs are conducted with the knowledge and understanding that the specific criteria under Limit 5 and Limit 6 of the 4(d) Rule must be met before take coverage under the ESA can be issued. Criteria for ESA evaluation of HGMPs that form RMPs submitted under Limit 6 are derived from (and therefore the same as for) Limit 5 (Artificial Propagation). HGMPs must:

1. Specify the goals and objectives for the hatchery program.
2. Specify the donor population's critical and viable threshold levels.
3. Prioritize broodstock collection programs to benefit listed fish.
4. Specify the protocols that will be used for spawning and raising the hatchery-origin fish.
5. Determine the genetic and ecological effects arising from the hatchery program.
6. Describe how the hatchery operation relates to fishery management.
7. Ensure that the hatchery facility can adequately accommodate listed fish if collected for the program.
8. Monitor and evaluate the management plan to ensure that it accomplishes its objective.
9. Be consistent with tribal trust obligations (65 Fed. Reg. 42422, July 10, 2000).

NMFS has a limited role (i.e., approve or deny) under Limit 6 of the 4(d) Rule. The decision as to whether the criteria under Limit 6 of the 4(d) Rule have been met will be documented in NMFS' ESA decision documents at the end of the ESA evaluation process. Under Limit 6 of the 4(d) Rule, NMFS will prepare a Pending Evaluation and Proposed Determination (PEPD) document for the proposed RMP and will take public comment on that document. Included with the ESA decision documents will be responses to comments on the HGMPs received during public review as required by the 4(d) Rule.

1.5.4 Biological Opinion on NMFS' Determination as to Compliance with the 4(d) Rule

Section 7(a)(2) of the ESA provides that any action authorized, funded, or carried out by a Federal agency shall not jeopardize the continued existence of any endangered or threatened species or result in the adverse modification or destruction of designated critical habitat. NMFS' actions under section 4(d) are Federal actions, and NMFS must comply with section 7(a)(2). NMFS' consultations under section 7 on those actions rely on the best available science, and therefore may be informed by this NEPA analysis. The results of these consultations are documented in biological opinions developed by NMFS and the U.S. Fish and Wildlife Service (USFWS; collectively the Services) for the species under their jurisdiction. Biological opinions are produced near the end of the ESA evaluation and determination process, providing the Services conclusions regarding the likelihood that the proposed hatchery actions would jeopardize the continued existence of any listed species or adversely modify designated critical habitat for any listed species.

1.6 Scoping and Relevant Issues

The first step in preparing an EIS is to conduct scoping of the issues that may be associated with the Proposed Action. This occurs through internal agency and public scoping processes. The purpose of scoping is to identify the relevant human environmental issues, to eliminate insignificant issues from detailed study, and to identify the alternatives to be analyzed in the EIS. Scoping can also help determine the level of analysis and the types of data required for analysis.

Scoping concluded (e.g., NMFS 2015) that the impacts of the proposed action on the human environment would be similarly negligible for some resources or parts of resources (water quality and human health, because hatchery operations would substantially comply with state clean water regulations, and wildlife, because there would be no substantial impacts on wildlife species). Therefore, these resources were not proposed to be analyzed (81 Fed. Reg. 26776, May 4, 2016). NEPA analyses of HGMPs for salmon and steelhead hatchery programs in a number of river basins reached similar conclusions. These analyses, which are listed below, were considered in the analyses of those resources in this EIS and incorporated by reference as appropriate.

- Final Environmental Assessment to Analyze Impacts of NOAA's National Marine Fisheries Service Determination that Five Hatchery Programs for Elwha River Salmon and Steelhead as Described in Joint State-Tribal Hatchery and Genetic Management Plans and One Tribal Harvest Plan Satisfy the Endangered Species Act Section 4(d) Rule – herein referred to as the Elwha FEA (NMFS 2012) (77 Fed. Reg. 75611, December 21, 2012)

- Final Supplemental Environmental Assessment to Analyze Impacts of NOAA's National Marine Fisheries Service Determination that Five Hatchery Programs for Elwha River Salmon and Steelhead as Described in Joint State-Tribal Hatchery and Genetic Management Plans and One Tribal Harvest Plan Satisfy the Endangered Species Act 4(d) Rule – herein referred to as the Elwha FSEA (NMFS 2014b) (79 Fed. Reg. 35318, June 20, 2014)

- Final Environmental Assessment to Analyze the Impacts of NOAA's National Marine Fisheries Service Determination that Three Hatchery Programs for Dungeness River Basin Salmon as Described in Joint State-Tribal Hatchery and Genetic Management Plans Satisfy the Endangered Species Act Section 4(d) Rule – herein referred to as the Dungeness Hatcheries FEA (NMFS 2016a)

- Final Environmental Assessment to Analyze the Impacts of NOAA's National Marine Fisheries Service Determination that 10 Hatchery Programs for Hood Canal Salmon and Steelhead as Described in Hatchery and Genetic Management Plans Satisfy the Endangered Species Act Section 4(d) Rule – herein referred to as the Hood Canal Hatcheries FEA (NMFS 2016b)

1.6.1 Notices of Public Scoping

Public scoping for this EIS commenced with publication of a Notice of Intent in the Federal Register on May 4, 2016 (81 Fed. Reg. 26776, May 4, 2016). That notice started a 30-day public comment period (May 4, 2016, to June 3, 2016) to gather information on the scope of the issues and the range of alternatives to be analyzed in the EIS. NMFS developed a website for the EIS at http://www.westcoast.fisheries.noaa.gov/hatcheries/salmon_and_steelhead_hatcheries.html. The website was available during the scoping period and will be updated and available throughout the project duration. Notifications of the public scoping process were distributed in emails to a list of over 4,200 addresses that had been compiled from people that commented on earlier hatchery EISs, including the PS Hatcheries DEIS (NMFS 2014a). Electronic and other notifications were sent to agencies, private individuals, businesses, and non-governmental organizations that contained a link to the website for this EIS and the address to the EIS electronic mailbox.

1.6.2 Written Comments Received during the Public Scoping Process

Submissions in writing received on this EIS during the public scoping process included:

- 1 letter from a governmental agency
- 20 emails from individual citizens

1.6.3 Issues Identified During Scoping

Based on all input received during the scoping process and in consideration of the purpose and need for the Proposed Action, input relevant to development of EIS alternatives generally included:

- Identify improvements in hatcheries and their operation that would reduce negative effects on natural-origin salmon and steelhead without reducing production.
- Modify hatchery programs to provide more fishing opportunities for salmon and steelhead.

Comments from public scoping also noted the importance of the need to address potential negative effects of releases from hatcheries on the salmon and steelhead resource, expressed concerns about genetics, and expressed concerns about degraded water quality in the lower reaches of the Duwamish-Green River Basin.

1.6.4 Future Public Review and Comment

There will be a number of opportunities for public review and comment under NEPA and the ESA associated with evaluations of the hatchery programs addressed in this EIS (Table 4). Under NEPA, this draft EIS has been issued for a 45-day public review period, which was announced in newspapers, through electronic distribution to interested parties, and by publication in the Federal Register. Following the public review period, public comments on the draft EIS will be considered and a final EIS will be prepared. Although not required by Council on Environmental Quality (CEQ) regulations, NMFS may consider public comments received on the final EIS in preparing the ROD. The ROD will be prepared no sooner than 30 days after the final EIS is released. Under Limit 6 of the 4(d) Rule, the PEPD document prepared by NMFS for the proposed RMP (Subsection 1.5.3, NMFS' Determination as to Compliance with the 4(d) Rule), will be made available for public review and comment for 30 days (Table 4).

Table 4. NMFS and USFWS documents and decisions required under the ESA and NEPA regarding salmon and steelhead hatchery programs, public notices, and comment opportunities.

Determination	Federal Register Notice of Intent and Public Scoping Comment Period	Federal Register Notice of Availability and Public Comment Period	Federal Register Notice of Availability and Public Access	Decision Document
ESA				
NMFS 4(d)		Pending Evaluation and Determination (30-day comment period)		Evaluation and Recommendation Determination[1]
NMFS BiOp[2]				Signed BiOp

Determination	Federal Register Notice of Intent and Public Scoping Comment Period	Federal Register Notice of Availability and Public Comment Period	Federal Register Notice of Availability and Public Access	Decision Document
USFWS BiOp				Signed BiOp
NEPA				
EIS[3]	Notice of Intent (30-day comment period)	Draft EIS (45-day comment period)	Final EIS (30-day "cooling off" period)	Record of Decision
Progression of Steps for Each Determination	Start	→	→	End

[1] Notification of decision published in Federal Register.
[2] BiOp = biological opinion under section 7 of the ESA.
[3] EIS = environmental impact statement.

After the ROD is prepared, if the co-managers propose substantive changes to the HGMPs reviewed in this EIS (including potential increases in hatchery production), or if substantial new information becomes available after completion of this EIS, additional NEPA compliance may be warranted. Such efforts could entail public review and comment on supplemental or new documents to the extent required by NEPA law and regulation.

1.7 Relationship to Other Plans and Policies

In addition to NEPA and ESA, other plans, regulations, agreements, treaties, laws, and Secretarial and Executive Orders also affect hatchery operations in the Duwamish-Green River Basin. They are summarized below to provide additional context for the hatchery programs and their proposed HGMPs (see Box 1-1), and the analyses in Chapter 3, Affected Environment, Chapter 4, Environmental Consequences, and Chapter 5, Cumulative Effects, of this EIS.

1.7.1 Clean Water Act

The Clean Water Act (33 United States Code [USC] 1251, 1977, as amended in 1987), administered by the U.S. Environmental Protection Agency (EPA) and state water quality agencies, is the principal Federal legislation directed at protecting water quality. Maintenance of high water quality consistent with the Clean Water Act is essential for ensuring the survival and productivity of natural-origin salmon and steelhead. The Act also helps ensure that the hatchery-origin fish produced under the Proposed Action (Subsection 1.2, Description of the Proposed Action) are supplied with clean water during rearing in the hatcheries, and after their release into the natural environment, to protect their health and foster their survival to return as adults. Each state implements and carries forth Federal provisions, as well as approves and reviews National Pollutant Discharge Elimination System (NPDES) applications, and establishes total maximum daily loads for rivers, lakes, and streams. The states are responsible for setting the water quality standards needed to support all beneficial uses, including protection of public health, recreational activities, aquatic life, and water supplies.

The Washington State Water Pollution Control Act, codified as Revised Code of Washington (RCW) Chapter 90.48, designates the Washington Department of Ecology (Ecology) as the agency responsible for carrying out the provisions of the Federal Clean Water Act within Washington State. The agency is responsible for establishing water quality standards, making and enforcing water quality rules, and operating waste discharge permit programs. These regulations are described in Washington Administrative Code (WAC) Title 173. Hatchery operations are typically required to comply with the Clean Water Act by maintaining active NPDES permits[2].

1.7.2 Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act (16 USC 668-668c), enacted in 1940, and amended several times since then, prohibits the taking of bald eagles, including their parts, nests, or eggs. The act defines “take” as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." The USFWS, who is responsible for carrying out provisions of this Act, defines “disturb” to include “injury to an eagle; a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior; or nest abandonment, by substantially interfering with normal breeding,

[2] Hatchery facilities and associated NPDES permit numbers: Soos Creek Hatchery (WAG13-3014); Icy Creek Pond (WAG13-3013); Palmer Pond (WAG13-3002); and Keta Creek Complex (WAG13-0020). Permits are not required under the Upland Fin-Fish Hatching and Rearing general NPDES permit for the Marine Technology Center, Des Moines Net Pens, Flaming Geyser Pond, Miller Creek Hatchery, and Elliott Bay Net Pens. Each of these facilities does not produce greater than 20,000 pounds of fish on site and does not use greater than 5,000 pounds of fish feed per month.

feeding, or sheltering behavior." As described in Subsection 3.4, Wildlife, and under the Proposed Action and alternatives analyzed in this EIS in Subsection 4.4, Wildlife, hatchery production has the potential to affect the productivity of eagles protected under this Act through changes in the number of salmon and steelhead available as prey.

1.7.3 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 (16 USC 1361) as amended, establishes a national policy designated to protect and conserve wild marine mammals and their habitats. This policy was established so as not to diminish such species or populations beyond the point at which they cease to be a significant functioning element in the ecosystem, nor to diminish such species below their optimum sustainable population. All marine mammals are protected under the MMPA.

The MMPA prohibits, with certain exceptions, the take of marine mammals in United States waters and by United States citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. The term "take," as defined by the MMPA, means to "harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." The MMPA further defines harassment as "any act of pursuit, torment, or annoyance, which (i) has the potential to injure a marine mammal or marine mammal stock in the wild; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing a disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild."

NMFS is responsible for reviewing Federal actions for compliance with the MMPA. As described in Subsection 3.4, Wildlife, and under the Proposed Action and alternatives analyzed in Subsection 4.4, Wildlife, hatchery production has the potential to indirectly affect marine mammals, including Southern Resident killer whales that are protected under the MMPA, through changes in the number of salmon and steelhead available as prey.

1.7.4 Executive Order 12898

In 1994, the President issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority and Low-income Populations*. The objectives of the Executive Order include developing Federal agency implementation strategies, identifying minority and low-income populations where proposed Federal actions could have disproportionately high and adverse human health and environmental effects, and encouraging the participation of minority and low-income populations in the NEPA process. As described in Subsection 3.6, Environmental Justice, and under the Proposed Action and alternatives analyzed in Subsection 4.6, Environmental Justice, hatchery production has the potential to affect the extent of harvest available for minority and low-income populations that are the focus of Executive Order 12898, including the Muckleshoot Indian Tribe and Suquamish Tribe.

1.7.5 Treaties of Point Elliott, Medicine Creek, and Point No Point

Beginning in the mid-1850s, the United States entered into a series of treaties with tribes in Puget Sound. The treaties were completed to secure the rights of the tribes to land and the use of natural resources in their historically inhabited areas, in exchange for the ceding of land to the United States for settlement by its citizens. The first treaty was the Treaty of Medicine Creek (signed in 1854), followed by two treaties signed in 1855: the Point Elliott Treaty and the Point No Point Treaty. These treaties secured the rights of tribes for taking fish at usual and accustomed grounds and stations in common with all citizens of the United States. Marine and freshwater areas of Puget Sound were affirmed as the usual and accustomed fishing areas for treaty tribes under *United States v. Washington* (1974).

The Muckleshoot Indian Tribe and Suquamish Tribe are signatories to the Treaty of Point Elliott, which is the lands settlement treaty between the United States government and the tribes of the North Puget Sound and Strait of Georgia area, in the recently-formed Washington Territory. The Treaty of Point Elliott was signed on January 22, 1855, at Muckl-te-oh or Point Elliott, now Mukilteo, Washington. The salmon and steelhead fishing rights of the Muckleshoot Indian Tribe and Suquamish Tribe in the usual and accustomed fishing areas are reserved under the treaties, in particular the Treaty of Point Elliott, and NMFS' Federal trust responsibility with respect to those rights as described in Subsection 1.7.7, Secretarial Order 3206, and Subsection 1.7.8, The Federal Trust Responsibility. The treaties complement the implementation of federally approved recovery plans for listed salmon and steelhead in Puget Sound (Subsection 1.7.12, Recovery Plans for Puget Sound Salmon and Steelhead). As described in Subsection 3.6, Environmental Justice, and under the Proposed Action and alternatives analyzed in Subsection 4.6, Environmental Justice, the treaty influences environmental impacts to minority and low income populations, including the Muckleshoot Indian Tribe and Suquamish Tribe.

1.7.6 United States v. Washington

Salmon and steelhead fisheries within the project area are jointly managed by the WDFW and Puget Sound treaty tribes (co-managers) under the continuing jurisdiction of *United States v. Washington* (1974). *United States v. Washington* (1974) is the Federal court proceeding that enforces and implements reserved treaty fishing rights with regard to salmon and steelhead returning to Puget Sound. Hatcheries in Puget Sound provide salmon and steelhead for these fisheries. Without many of these hatcheries, there would be few, if any, fish for the tribes to harvest (Stay 2012; Northwest Indian Fisheries Commission [NWIFC] 2013). These fishing rights and attendant access were established by treaties the Federal government signed with the tribes in the 1850s (Subsection 1.7.5, Treaties of Point Elliott, Medicine Creek, and Point No Point). In those treaties, the tribes agreed to allow the peaceful settlement of Indian lands in western Washington in exchange for their continued right to fish, gather shellfish, hunt, and exercise other sovereign rights. In 1974, Judge George Boldt decided in *United States v. Washington* that the tribes' fair and equitable share was 50 percent of all of the harvestable fish destined for the tribes' traditional fishing places. Hatchery-origin fish are considered fish to the same extent as natural-origin fish and, thus, are counted in the determination of the treaty share (*United States v. Washington*, 759 F.2d 1353, 1358-60 (9th Cir.), cert. denied, 474 U.S. 994 [1985]). In the recent ruling in the Culverts subproceeding of *United States v. Washington*, the Federal District Court held that the treaty right imposes a duty on the state to refrain from degrading salmon and steelhead habitat by maintaining fish-blocking culverts on state roads and highways (20 F. Supp. 3d 828, 889 [W.D. Wa. 2007], aff'd 2220 F.3d 836 [9th Cir. 2016]). The joint state-tribal RMPs submitted to NMFS for review and approval under Limit 6 of the 4(d) Rule, including the HGMPs described under the Proposed Action, are implemented within the parameters of *United States v. Washington*.

1.7.7 Secretarial Order 3206

Secretarial Order 3206 (*American Indian Tribal Rights, Federal-Tribal Trust Responsibilities and the ESA*, http://www.nmfs.noaa.gov/sfa/reg_svcs/Councils/Webinar/secretarial_order.pdf), issued by the secretaries of the Departments of Interior and Commerce, clarifies the responsibilities of the agencies, bureaus, and offices of the departments when actions taken under the ESA and its implementing regulations affect, or may affect, Indian lands, tribal trust resources, or the exercise of American Indian tribal rights as they are defined in the Order. The Secretarial Order acknowledges the trust responsibility and treaty obligations of the United States toward tribes and tribal members, as well as its government-to-government relationship when corresponding with tribes. Under the Order, the Services "will carry out their responsibilities under the [ESA] in a manner that harmonizes the Federal trust responsibility to tribes, tribal sovereignty, and statutory missions of the [Services], and that strives to ensure that Indian tribes do not bear a disproportionate burden for the conservation of listed species, so as to avoid or minimize the potential for conflict and confrontation."

In the event that the Services determine that conservation restrictions directed at a tribal activity are necessary to protect listed species, specifically where the activity could result in incidental take under the ESA, the Services shall provide the affected tribe(s) written notice, including an analysis and determination that (i) the restriction is reasonable and necessary for conservation of the species; (ii) the conservation purpose of the restriction cannot be achieved by reasonable regulation of non-Indian activities; (iii) the measure is the least restrictive alternative available to achieve the required conservation purpose; (iv) the restriction does not discriminate against Indian activities, either as stated or applied; and (v) voluntary tribal measures are not adequate to achieve the necessary conservation purpose.

More specifically, the Services shall, among other things, do the following:

- Work directly with Indian tribes on a government-to-government basis to promote healthy ecosystems (Section 5, Principle 1).
- Recognize that Indian lands are not subject to the same controls as Federal public lands (Section 5, Principle 2).
- Assist Indian tribes in developing and expanding tribal programs so that healthy ecosystems are promoted and conservation restrictions are unnecessary (Section 5, Principle 3).
- Be sensitive to Indian culture, religion, and spirituality (Section 5, Principle 4).

Additionally, the U.S. Department of Commerce issued a Departmental Administrative Order (DAO) addressing Consultation and Coordination with Indian Tribal Governments (DAO 218-8, April 26, 2012; http://www.osec.doc.gov/opog/dmp/daos/dao218_8.html), which implements relevant Executive Orders, Presidential Memoranda, and Office of Management and Budget Guidance. The DAO describes actions to be "followed by all Department of Commerce operating units … and outlines the principles governing Departmental interactions with Indian tribal governments." The DAO affirms that the "Department works with Tribes on a government-to-government basis to address issues concerning … tribal trust resources, tribal treaty, and other rights."

Secretarial Order 3206 and the DAO affect the Federal process described in Subsection 1.6, Scoping and Relevant Issues, and relationships influencing the analysis of resources evaluated in this EIS, including Subsection 4.2, Salmon and Steelhead, Subsection 4.5, Socioeconomics, and Subsection 4.6, Environmental Justice.

1.7.8 The Federal Trust Responsibility

The United States government has a trust or special relationship with Indian tribes. The unique and distinctive political relationship between the United States and Indian tribes is defined by statutes, executive orders, judicial decisions, and agreements and differentiates tribes from other entities that deal with, or are affected by, the Federal government. Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments*, states that the United States has recognized Indian tribes as domestic dependent nations under its protection. The Federal government has enacted numerous statutes and promulgated numerous regulations that establish and define a trust relationship with Indian tribes.

The relationship has been compared to one existing under common law trust, with the United States as trustee, the Indian tribes or individuals as beneficiaries, and the property and natural resources of the United States as the trust corpus (Newton et al. 2005). The trust responsibility has been interpreted to require Federal agencies to carry out their activities in a manner that is protective of Indian treaty rights. This policy is also reflected in the March 30, 1995, document, *Department of Commerce – American Indian and Alaska Native Policy* (U.S. Department of Commerce 1995). The Ninth Circuit Court of Appeals has held, however, that "unless there is a specific duty that has been placed on the government with respect to Indians, [the government's general trust obligation] is discharged by [the government's] compliance with general regulations and statutes not specifically aimed at protecting Indian tribes" (Gros Ventre Tribe v. United States, 2006, citing Morongo Band of Mission Indians v. FAA, 1998; United States v. Jicarilla Apache Nation, U.S., 131 S.Ct. 2313, 180 L.Ed.2nd 187, 2011).

As an agency mandate, NMFS' implementation of its Federal trust responsibilities influences the analysis of resources evaluated in this EIS, especially regarding Subsection 4.2, Salmon and Steelhead, Subsection 4.5, Socioeconomics, and Subsection 4.6, Environmental Justice.

1.7.9 Tribal Policy for Salmon Hatcheries

The Puget Sound treaty tribes' (tribes) *Tribal Policy Statement for Salmon Hatcheries in the Face of Treaty Rights at Risk* (NWIFC 2013) was submitted to NMFS and WDFW by the tribes for the purpose of reaffirming "the role salmon and steelhead hatcheries play in implementing the treaty right to fish and in recovering salmon populations in the face of continuing loss of salmon habitat by degradation and climate change." The Policy acknowledges that state and Federal governments historically developed and used hatcheries as a means of mitigating for the loss of habitat and natural production they had permitted. The Policy states that "As long as watersheds, the Salish Sea estuary, and the ocean are unable to maintain self-sustaining salmon populations in sufficient abundance, hatcheries will remain an integral and indispensable component of salmon management. Hatcheries are necessary for tribes to be able to harvest salmon in their traditional areas to carry out the promises of the treaties fully and meet the requirements of *United States vs. Washington* and *Hoh vs. Baldrige*." The analyses in this

EIS take into account the need to protect tribal trust resources as described in Subsection 1.7.8, The Federal Trust Responsibility, including the contributions of hatcheries under the Proposed Action and the alternatives, to meeting treaty reserved fishing rights.

1.7.10 Washington State Endangered, Threatened, and Sensitive Species Act

This EIS considers the effects of hatchery programs and harvest actions on state endangered, threatened, and sensitive species that have a relationship with salmon and steelhead. The State of Washington has species of concern listings (Washington Administrative Code [WAC] Chapters 232-12-014 and 232-12-011) that include all state endangered, threatened, sensitive, and candidate species. These species are managed by WDFW, as needed, to prevent them from becoming endangered, threatened, or sensitive. The state-listed species are identified on WDFW's website (http://wdfw.wa.gov/conservation/endangered/lists/); the most recent update occurred in February 2017. The criteria for listing and de-listing, and the requirements for recovery and management plans for these species are provided in WAC Chapter 232-12-297. The state list is separate from the Federal ESA list; the state list includes species status relative to Washington State jurisdiction only. Critical wildlife habitats associated with state or federally listed species are identified in WAC Chapter 222-16-080. Species on the state endangered, threatened, and sensitive species list are reviewed in this EIS if the Proposed Action and the alternatives could affect these species (Subsection 3.4, Wildlife, and Subsection 4.4, Wildlife).

1.7.11 Hatchery and Fishery Reform Policy

WDFW's Hatchery and Fishery Reform Policy (Policy C-3619) was adopted by the Washington Fish and Wildlife Commission in 2009 (Washington Fish and Wildlife Commission 2009). It supersedes WDFW's Wild Salmonid Policy, which was adopted in 1997. Its purpose is to advance the conservation and recovery of wild salmon and steelhead by promoting and guiding the implementation of hatchery reform. The policy applies to WDFW hatchery actions included under the Proposed Action and the alternatives reviewed in this EIS. It is NMFS' understanding that the HGMPs WDFW submitted to NMFS for review and approval were prepared with the intent to improve hatchery effectiveness, ensure compatibility between hatchery production and salmon recovery plans and rebuilding programs, and support sustainable fisheries.

1.7.12 Recovery Plans for Puget Sound Salmon and Steelhead

A Federal recovery plan associated with the project area addressed in this EIS is in place for the ESA-listed Puget Sound Chinook salmon (NMFS 2006; Shared Strategy for Puget Sound 2007; 72 Fed.

Reg. 2493, January 19, 2007). Broad partnerships of Federal, state, local, and tribal governments and community organizations collaborated in the development of the recovery plan under Washington's Salmon Recovery Act. The comprehensive recovery plan includes conservation goals and proposed habitat, hatchery, and harvest actions needed to achieve the conservation goals for each watershed within the geographic boundaries of the listed ESUs. Subsequently, NMFS released for public review a draft framework (the Population Recovery Approach [PRA]) that categorized the relative role of each Chinook salmon population and watershed that supports them for consultation and recovery planning purposes, into one of three "tiers[3]" (75 Fed. Reg. 82208, December 29, 2010). The Green River Chinook salmon population and watershed are in Tier 2. Tier 2 populations are of secondary importance for recovery, compared to Tier 1 populations which must achieve low extinction risk status. Although the Puget Sound Steelhead DPS was listed in 2007, a recovery plan has not yet been completed, but is currently in the process of assembly. A draft plan is projected to be completed in 2018 with a final plan completed in 2019 (http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/puget_sound/overview_puget_sound_steelhead_recovery_2.html). The recovery plans as well as the required 5-year status assessments produced by NMFS provide information that is fundamental to the analysis of existing conditions for listed salmon and steelhead resources (Subsection 3.2, Salmon and Steelhead), and the analysis of effects on listed salmon and steelhead under the Proposed Action and the alternatives (Subsection 4.2, Salmon and Steelhead).

1.8 Organization of this Draft EIS

The EIS should be reviewed in conjunction with the co-managers' HGMPs for the 10 Duwamish-Green River Basin salmon and steelhead hatchery programs (http://www.westcoast.fisheries.noaa.gov/hatcheries/Duwamish-Green/duw-green_hgmps.html), which contain more detailed information and explanations of hatchery programs affecting Puget Sound resources. Links to online sources of information used in the EIS are active at the time of publication;

[3] Under the PRA, Tier 1 Chinook salmon populations are of primary importance for preservation, restoration, and ESU recovery and have to be viable for the ESU as a whole to meet viability criteria in Ruckelshaus et al. (2002). If not assigned to Tier 1, populations with cumulative scores relative to the ESU-wide mean that are greater than the ESU-wide mean are assigned to Tier 2, whereas scores below the ESU-wide mean are assigned to Tier 3. Impacts on Tier 1 populations would be more likely to affect the viability of the ESU as a whole than similar impacts on Tier 2 or Tier 3 populations, because of the primary importance of Tier 1 populations to overall ESU viability. Tier 2 populations would be less important for recovery to a low extinction risk status. Tier 3 populations would be allowed to absorb more effects, but would still require ESA protection so that the populations maintains a trajectory toward recovery, albeit over a longer term than for Tier 1 and Tier 2 populations (NMFS 2010).

however, NMFS cannot guarantee that they will remain active over time. The contents of this EIS are described briefly below:

- **Introductory Materials**. Prior to Chapter 1 are a cover sheet, summary, list of acronyms, glossary of key terms, and table of contents.
- **Chapter 1**. This chapter provides the background and context leading to the development of the Proposed Action. It describes the purpose and need for the action; background and decisions to be made; scoping and relevant issues; and the relationship of this action to other plans, regulations, and laws.
- **Chapter 2**. This chapter describes each of the alternatives and lists their major components. The No-action Alternative is included, along with three action alternatives, including the Proposed Action, and alternatives considered but not analyzed in detail.
- **Chapter 3**. This chapter describes the existing environmental setting (i.e., existing conditions) that would be affected by the alternatives. It includes subsections on water quantity and quality, salmon and steelhead, other fish species, wildlife (Southern Resident killer whales), socioeconomics, environmental justice, and human health resources.
- **Chapter 4**. This chapter contains descriptions and analyses of the potential direct and indirect effects of each alternative on the resources identified in Chapter 3. It also compares the action alternatives to the No-action Alternative.
- **Chapter 5**. This chapter addresses cumulative impacts, which are the incremental effects of an action when added to other past, present, and reasonably foreseeable actions, regardless of what agency or person undertakes such actions. Climate change is addressed in this chapter.
- **Remaining Material**. This material includes a list of references, distribution list, list of preparers, index, and appendices.

Chapter 2

2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

This chapter describes the four alternatives evaluated in this EIS. The alternatives are fully described in this chapter, and their environmental effects are presented in Chapter 4, Environmental Consequences. Specifically, this chapter describes the following:

- How the alternatives were developed
- Alternatives that were analyzed in detail
- Alternatives that were considered but eliminated from detailed analysis

2.1 Development of Alternatives

In 2016, NMFS solicited and considered public comment on the development of alternatives for this EIS (Subsection 1.6, Scoping and Relevant Issues). In the Notice of Intent to develop this EIS (81 Fed. Reg. 26776, May 4, 2016), NMFS identified three alternatives for possible analysis: the Proposed Action (NMFS' approval under the 4(d) Rule of implementation of the co-managers' HGMPs), no action (no NMFS approval of the HGMPs under the 4(d) Rule), and a decreased hatchery production alternative (50 percent decrease in number of salmon and steelhead released and NMFS approval of the HGMPs under the 4(d) Rule).

The scoping process (Subsection 1.6, Scoping and Relevant Issues) identified eight potential alternatives, including those proposed in the Notice of Intent. Of these eight alternatives, four were found to represent the full range of reasonable alternatives because their components differed meaningfully from the other alternatives analyzed. Two of the alternatives other than the No-action Alternative (Proposed Action and Reduced Production), meet the purpose and need for the Proposed Action. Four potential alternatives were carefully considered but eliminated from detailed analysis because (1) they are already encompassed by other alternatives analyzed in detail and thus would not provide substantive new information for the decision-maker to consider, or (2) do not meet the purpose and need for the Proposed Action.

2.2 Alternatives Analyzed in Detail

Four alternatives are evaluated in this EIS: (1) NMFS would not make a determination under the 4(d) Rule (No Action), (2) NMFS would make a determination that the submitted HGMPs meet requirements of the 4(d) Rule (Proposed Action), (3) NMFS would make a determination that the submitted HGMPs would not meet the requirements of the 4(d) Rule (Termination), and (4) NMFS would make a determination that revised HGMPs with reduced production levels would meet requirements of the 4(d) Rule (Reduced Production). Maximum annual production levels by species under the alternatives are summarized in Table 5.

Table 5. Maximum annual hatchery releases of juvenile salmon and steelhead under the alternatives by species.

Species	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Fall-run Chinook salmon[1]	5,100,000	5,100,000	0	2,550,000
Late winter-run steelhead [2]	383,000	383,000	0	191,500
Summer-run steelhead[3]	100,000	100,000	0	50,000
Coho salmon[4]	3,410,000	3,410,000	0	1,705,000
Chum salmon[5]	5,000,000	5,000,000	0	2,500,000
Total	**13,993,000**	**13,993,000**	**0**	**6,996,500**

Sources: Muckleshoot Indian Tribe 2014a, 2014b, 2014c, 2014d; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014b, 2014c, 2015

[1] Applies to the Soos Creek fall-run HGMP and the FRF fall-run Chinook salmon HGMP.

[2] Applies to the Green River late winter-run steelhead HGMP and the FRF late winter-run steelhead HGMP.

[3] Applies to the Soos Creek summer-run steelhead HGMP.

[4] Applies to the Soos Creek coho salmon HGMP, Keta Creek coho salmon HGMP, Marine Technology Center coho salmon HGMP, and the FRF coho salmon HGMP.

[5] Applies to the Keta Creek chum salmon HGMP.

Monitoring activities would be part of the provisions of approved HGMPs under Alternative 2 and Alternative 4 (Table 2), and would include, but not be limited to, obtaining information on smolt-to-adult survival, fishery contribution, natural-origin and hatchery-origin spawning abundance, juvenile out-migrant abundance and diversity, genetics, and juvenile and adult fish health when the fish are in the hatchery.

2.2.1 Alternative 1 (No Action) – Do Not Make a Determination under the 4(d) Rule

Under this alternative, NMFS would not make a determination under the 4(d) Rule for any of the 10 HGMPs, and the hatchery programs would not be exempted from ESA section 9 take prohibitions. If the programs are not authorized under the No-action Alternative, several possible outcomes could occur:

- The applicants could pursue obtaining an ESA section 10(a)(1)(B) incidental take permit to exempt the hatchery programs from take prohibitions.
- The applicants could choose to operate the hatchery programs without ESA authorization and be liable for ESA take violations.
- The applicants could choose to terminate the hatchery programs because they would not have ESA authorization.

For the purposes of this analysis, NMFS has defined the No-action Alternative as the choice by the applicants to continue the hatchery programs without ESA authorization. NMFS made this choice for a variety of reasons, including the lengthy history of ongoing operations and the existence of tribal treaty rights for harvest that is at least partly related to the production. The applicants would continue to operate the hatchery programs as under existing conditions. For the purposes of this analysis, production from the three FRF hatchery programs would be included under Alternative 1, as described in Subsection 2.2.2, Alternative 2 (Proposed Action), and a maximum of 13,993,000 hatchery-origin salmon and steelhead would be released annually (Table 5). No new environmental protection or enhancement measures would be implemented. Monitoring as described in the HGMPs may or may not occur.

The No-action Alternative represents NMFS' best estimate of what may happen in the absence of the Proposed Action.

2.2.2 Alternative 2 (Proposed Action) – Make a Determination that the Submitted HGMPs Meet the Requirements of the 4(d) Rule

Under this alternative, NMFS would make a determination that the HGMPs submitted by the co-managers meet requirements of the 4(d) Rule. The 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin would be implemented as described in the 10 submitted HGMPs (Muckleshoot Indian Tribe 2014a, 2014b, 2014c, 2014d; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014b, 2014c, 2015) and Subsection 1.2, Description of the Proposed Action.

Under Alternative 2, the total annual maximum release level would be 13,993,000 hatchery-origin salmon and steelhead (Table 5) as follows:

- Fall-run Chinook salmon up to 5,100,000
- Late winter-run steelhead up to 383,000
- Summer-run steelhead up to 100,000
- Coho salmon up to 3,410,000
- Chum salmon up to 5,000,000

Although 1,550,000 salmon and steelhead would be released for the three FRF hatchery programs, the life stages of fish released would differ depending on whether downstream passage facilities for juveniles are provided at Howard Hanson Dam. If downstream fish passage is not available at Howard Hanson Dam, all fish releases from the three programs would occur below the dam (600,000 fall-run Chinook salmon subyearlings, 350,000 steelhead yearlings, and 600,000 coho salmon yearlings). If downstream fish passage is available, most fish would be released at earlier life stages and into areas in the upper watershed above the dam, as described in Table 3. The releases above the dam would total 1,280,000 fish, including 500,000 fall-run Chinook salmon fry, 280,000 late winter-run steelhead fry, and 500,000 coho salmon fry. A total of 270,000 salmon and steelhead would be released below the dam. Environmental effects of both fish release scenarios (i.e., with and without downstream fish passage) are evaluated in this EIS for the three FRF hatchery programs.

The hatchery programs would use hatchery capacity as described in the HGMPs for operations, and would be adaptively managed over time to incorporate best management practices (BMPs) as new information is available. These may include practices such as reducing release levels during times of extremely poor ocean survival, or developing water re-use or recirculation systems or contingency plans for hatchery operations at times of low flow and high water temperature.

2.2.3 Alternative 3 (Termination) – Make a Determination that the Submitted HGMPs Do Not Meet the Requirements of the 4(d) Rule

Under this alternative, NMFS would make a determination that the HGMPs as proposed do not meet the standards prescribed under Limit 5 and Limit 6 of the 4(d) Rule, and the 10 salmon and steelhead hatchery programs in the Duwamish-Green River Basin would be terminated. All salmon and steelhead being raised in hatchery facilities (i.e., fall-run Chinook salmon, late winter-run steelhead, summer-run steelhead, coho salmon, and chum salmon) would be released or killed, and no broodstock would be collected.

NMFS does not expect this alternative to meet the applicants' objectives for the action because substantial progress toward Chinook salmon and steelhead conservation and recovery in the Duwamish-Green River Basin would be unlikely under this alternative. Additionally, this alternative would not fulfill treaty-reserved fishing rights or provide fishing opportunities for citizens of Washington State. However, NMFS supports analysis of this alternative to assist with a full understanding of potential effects on the human environment under various management scenarios, including those that do not achieve all of the applicants' specific objectives. This is useful where existing conditions include hatchery effects as an ongoing feature. This termination alternative assists NMFS in comparing the Proposed Action to a hypothetical environment without hatcheries, which is important for gauging the extent of effects resulting from the Proposed Action.

2.2.4 Alternative 4 (Reduced Production) – Make a Determination that Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

Under this alternative, the applicants would reduce the number of fish released from each of the 10 proposed hatchery programs. Revised HGMPs would be submitted reflecting these reduced production levels, and NMFS would make a determination that the revised HGMPs meet the requirements of the 4(d) Rule.

For the purposes of analysis, NMFS will evaluate a 50 percent reduction from the proposed hatchery programs (total releases would be up to 6,996,500 hatchery-origin juveniles) because it represents a mid-point between the Proposed Action (Alternative 2) and Alternative 3 (Termination). Note that NMFS' regulations under the 4(d) Rule do not provide NMFS with the authority to order changes of this magnitude as a condition of approval of the HGMPs. NMFS' regulations under the 4(d) Rule require NMFS to make a determination that the HGMPs *as proposed* either meet or do not meet the standards prescribed under Limit 5 and Limit 6 of the 4(d) Rule. Nonetheless, NMFS supports analysis of this alternative to assist with a full understanding of potential effects on the human environment under various management scenarios.

Under Alternative 4, the total annual maximum release level would be 6,996,000 hatchery-origin salmon and steelhead (Table 5) as follows:

- Fall-run Chinook salmon up to 2,550,000
- Late winter-run steelhead up to 191,500

- Summer-run steelhead up to 50,000
- Coho salmon up to 1,705,000
- Chum salmon up to 2,500,000

Although 775,000 salmon and steelhead would be released for the three FRF hatchery programs, the life stages at which the fish would be released would differ depending on whether downstream passage for juveniles is provided at Howard Hanson Dam. If downstream fish passage is not available at Howard Hanson Dam, all fish releases from the three programs would occur below the dam (300,000 fall-run Chinook salmon subyearlings, 175,000 steelhead yearlings, and 300,000 coho salmon yearlings). If downstream fish passage is available, most fish would be released at earlier life stages and into areas in the upper watershed above the dam, as described in Table 3. The releases above the dam would total 640,000 fish, including 250,000 fall-run Chinook salmon fry, 140,000 late winter-run steelhead fry, and 250,000 coho salmon fry. A total of 135,000 salmon and steelhead would be released below the dam. Environmental effects of both fish release scenarios (i.e., with and without downstream fish passage) are evaluated in this EIS for the three FRF hatchery programs.

2.3 Alternatives Considered But Not Analyzed in Detail

The following additional four alternatives identified during the scoping processes (Subsection 1.6, Scoping and Relevant Issues), were carefully considered, but NMFS determined that (1) they are already encompassed by other alternatives analyzed in detail and thus would not provide substantive new information for the decision-maker to consider, or (2) do not meet the purpose and need for the Proposed Action (Subsection 1.3, Purpose of and Need for the Proposed Action). These alternatives are:

- Increase production of hatchery-origin fish.
- Incorporate recommendations or reforms to maximize hatchery program performance at levels of production identified in submitted HGMPs.
- Maximize recovery potential for listed species.
- Use additional BMPs.

<u>Hatchery programs with greater levels of hatchery production than those proposed</u> – Under this potential alternative, the co-managers (WDFW, Muckleshoot Indian Tribe, and Suquamish Tribe) would revise their HGMPs to incorporate substantially higher production levels than those proposed, primarily to increase fishery benefits. This alternative is not analyzed in detail because substantially

higher production levels would exceed fish rearing density limits for the hatchery facilities and result in increasingly negative fish health and survival impacts on the hatchery-origin fish. In addition, substantially higher production levels may increase negative effects outside of the hatchery facility (e.g., competition and predation on natural-origin salmon and steelhead and other fish species). Constructing additional hatchery facilities to accommodate substantially increased production would not meet the purpose and need for the action, which includes using existing hatchery facilities described in the HGMPs. In addition, substantially higher production levels would have greater negative impacts than under the Proposed Action and would not meet NMFS' need to protect and conserve listed species.

<u>Incorporate recommendations or reforms to maximize hatchery performance at proposed production levels</u> – Under this potential alternative, identified improvements to hatchery programs (e.g., independent recommendations of the Hatchery Scientific Reviews Group [HSRG] from 2002 to 2004; or potential improvements as identified in HGMPs) would be implemented as an action alternative, but at the same production levels as under the Proposed Action. The Washington Recreation and Conservation Office (RCO) (RCO 2014) indicates continuing and substantial progress has been made in increasing the percentage of WDFW's Puget Sound hatchery programs that meet HSRG standards. In addition, HSRG and related recommendations are already being incorporated into HGMPs, and the co-managers intend to continue to implement such recommendations (including monitoring and evaluation) over time using adaptive management under the Proposed Action. Thus, this potential alternative is not analyzed in detail because it would not be meaningfully different from the Proposed Action as it relates to the purpose and need.

<u>Maximize recovery potential for listed species</u> **–** Under this potential alternative, the hatchery programs would be designed to reduce risks to and increase benefits for the recovery of listed species. However, under the action alternatives, the numbers of released salmon and steelhead would be reduced (Alternative 4) or terminated (Alternative 3), effectively reducing or eliminating risks to listed species from the programs. In addition, under the Proposed Action, 8 of the 10 hatchery programs are integrated hatchery programs, which are intended to contribute to the conservation and recovery of listed species. The two isolated programs are the Soos Creek summer-run steelhead hatchery program and the Marine Technology Center coho salmon program, which would produce only 110,000 of the 13,993,000 fish under the Proposed Action. Thus for the above reasons, this potential alternative is not analyzed in detail because it would not be measurably different from the action alternatives.

Use additional BMPs – Under this potential alternative, NMFS would approve the 10 proposed hatchery programs and require implementation of additional BMPs to further reduce the risk of adverse impacts of the hatchery programs on natural-origin salmon and steelhead populations. Similar to the alternative considered above (Incorporate recommendations or reforms to maximize hatchery performance at proposed production levels), because the proposed HGMPs have already incorporated BMPs identified by independent reviewers and because the HGMPs allow for the incorporation of additional BMPs in the future as a result of monitoring and evaluation activities, this alternative would not be meaningfully different from the Proposed Action and is not analyzed in detail.

Chapter 3

3 AFFECTED ENVIRONMENT

Chapter 3, Affected Environment, describes existing conditions for six resources that may be affected by implementation of the EIS alternatives:

- Water Quantity and Quality (Subsection 3.1)
- Salmon and Steelhead (Subsection 3.2)
- Other Fish Species (Subsection 3.3)
- Wildlife – Southern Resident Killer Whale (Subsection 3.4)
- Socioeconomics (Subsection 3.5)
- Environmental Justice (Subsection 3.6)
- Human Health (Subsection 3.7)

No other resources were identified during scoping that would have the potential to be significantly impacted by the Proposed Action or other alternatives (Subsection 1.6, Scoping and Relevant Issues). Additionally, as discussed in Subsection 1.6, Scoping and Relevant Issues, the analyses of salmon and steelhead hatchery programs in Puget Sound watersheds in the PS Hatcheries DEIS (NMFS 2014a) suggests that water quality, human health, and wildlife (other than Southern Resident killer whale) resources are unlikely to have the potential to be substantially impacted by the Proposed Action or alternatives. Therefore, analyses of water quality, wildlife (other than Southern Resident killer whale), and human health in the information and findings in the PS Hatcheries DEIS are incorporated by reference and summarized in appropriate subsections in Chapter 3, Affected Environment, and Chapter 4, Environmental Consequences, in this EIS.

Existing conditions within the project area include effects of the past and present operation of salmon and steelhead hatchery programs in the Duwamish-Green River Basin (Subsection 1.4, Project and

Analysis Areas). Under existing conditions[4], seven salmon and steelhead hatchery programs in the Duwamish-Green River Basin (Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities) produce up to 12,443,000 juveniles annually as follows:

- Fall-run Chinook salmon: up to 4,500,000 subyearlings and yearlings
- Late winter-run steelhead: up to 33,000 yearlings
- Summer-run steelhead: up to 100,000 yearlings
- Coho salmon: up to 2,810,000 yearlings and fry
- Chum salmon: up to 5,000,000 fry

The alternatives evaluated in this EIS are likely to result in more direct, indirect, and cumulative effects on salmon and steelhead than on other resources. Consequently, this EIS contains more information for salmon and steelhead resources than for the other resources analyzed. This is because, in contrast to the other resources, effects of the hatchery programs on salmon and steelhead resources under the alternatives would be expected to occur in areas other than the locations of the hatchery facilities used to produce the fish. For example, effects would be expected to occur in areas farther away, including upstream spawning areas, and marine areas through which juvenile and adult salmon and steelhead pass on their way to and from the ocean.

The effects of the hatchery programs under existing conditions are summarized using the following terms:

Undetectable:	The impact is not detectable.
Negligible:	The impact is at the lower levels of detection, and can be either positive or negative.
Low:	The impact is slight, but detectable, and can be either positive or negative.
Moderate:	The impact is readily apparent, and can be either positive or negative.
High:	The impact is greatly positive or severely negative.

[4] There are three programs associated with the FRF – one for fall-run Chinook salmon, one for late winter-run steelhead, and one for coho salmon – that are part of the Proposed Action but are not reviewed in Chapter 3, Affected Environment, because the hatchery facilities for those three programs have not been constructed. However, these hatchery programs are described and analyzed in Chapter 4, Environmental Consequences.

3.1 Water Quantity and Quality

3.1.1 Water Quantity

Streamflows in the Duwamish-Green River Basin where the hatchery facilities are located are driven primarily by rain, with contributions of snowmelt from the river's headwaters in the west slope of the Cascade Mountains. Groundwater inputs to the Green River are also important, especially during low flow periods, including where groundwater from the adjacent White River Basin connects to the Green River and several large springs in the upper watershed (feeding Icy Creek, Black Diamond and Palmer Springs) (King County 2005). Historically, average flow in the lower Green River (measured at a stream gage near Auburn) ranged between 140 cubic feet per second (cfs) and 28,000 to 30,000 cfs (Kerwin and Nelson 2000). The watershed area and flows were permanently reduced by 70 percent when the historical White, Black, and Cedar Rivers (including Lakes Washington and Sammamish) were diverted away from the Duwamish-Green River Basin (King County 2005). Following construction of Howard Hanson Dam, the average minimum flow increased to 210 cfs, and maximum recorded flow decreased to approximately 11,500 cfs, with a current average annual flow of 1,350 cfs (Kerwin and Nelson 2000). Howard Hanson Dam is operated by the USACE for flood control and to provide low-flow augmentation during the summer and early fall. Instream flow needs during this period include protections for redds of naturally spawning winter-run steelhead, juvenile salmon and steelhead rearing in streams, and Chinook salmon spawning (King County 2005).

Hatchery programs can affect water quantity when groundwater from an aquifer is removed via a well or spring, or when surface water from a neighboring river or tributary stream is removed for use in the hatchery facilities for broodstock holding, egg incubation, juvenile rearing, and juvenile acclimation. All water used from groundwater or surface water sources, minus evaporation, is discharged into the water course adjacent to the hatchery rearing location after it circulates through the hatchery facility (non-consumptive use[5]). When hatchery programs use groundwater (i.e., from wells or springs), the amount of water available for other users in the same aquifer is reduced. When hatchery programs use surface water, the use may lead to dewatering of the stream between the water intake and discharge structures (called the bypass reach), which may impact fish and wildlife if migration is impeded or dewatering leads to increased water temperatures. Generally, water intake and discharge structures are located as close together as possible to minimize the area of the stream that may be impacted by a water withdrawal. Additional detail regarding water use and information on water quantity conditions

[5] Unless otherwise noted, terms associated with analyses of water quantity (e.g., consumptive, dewater, benefit) are used in the EIS specifically for the purposes of the analysis, and are not intended to be synonymous with similar terms under Washington's water law (e.g., "consumptive," "beneficial uses").

in the analysis area associated with hatchery programs can be found in Subsection 3.6, Water Quantity, in the PS Hatcheries DEIS (NMFS 2014a). The analysis area for water quantity is the same as the project area (Subsection 1.4, Project and Analysis Areas).

Considering water requirements for hatchery operations, more water is needed for hatchery rearing of yearlings, and less water is needed for rearing of subyearlings and fry. In addition, water is needed for broodstock collection and incubation. Although water re-use is possible, high water quality for juvenile growth is important for their survival in hatchery rearing areas; thus, additional expenses are incurred to maintain sufficient water quality when hatchery water is re-used. For the salmon and steelhead species and life stages released in the Duwamish-Green River Basin, juveniles are released from April to June (Table 3.2-4, PS Hatcheries DEIS [NMFS 2014a]) when higher stream flows are occurring from snow melt, rain, and from releases of water from Howard Hanson Dam. As a result, maximum water requirements for hatcheries within the Duwamish-Green River Basin do not occur during low-flow stream conditions in late summer.

As shown in Table 1, there are 10 primary hatchery facilities used to support the 7 existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin (the 3 FRF hatchery programs in the Proposed Action have not been constructed). The salmon and steelhead hatchery programs and associated hatchery facilities are:

• Soos Creek fall-run Chinook salmon program	Soos Creek Hatchery Icy Creek Pond Palmer Pond
• Green River late winter-run steelhead program	Soos Creek Hatchery Icy Creek Pond Flaming Geyser Pond Palmer Pond
• Soos Creek summer-run steelhead program	Soos Creek Hatchery Icy Creek Pond
• Soos Creek coho salmon program	Soos Creek Hatchery Miller Creek Hatchery Des Moines Marina Net Pens
• Keta Creek Complex coho salmon program	Soos Creek Hatchery Keta Creek Hatchery Elliott Bay Net Pens
• Marine Technology Center coho salmon program	Marine Technology Center Soos Creek Hatchery
• Keta Creek Complex chum salmon program	Keta Creek Hatchery

These facilities consist of four hatcheries, three rearing pond facilities, and two net pens along the marine shoreline. Six of the existing facilities use surface and/or spring water exclusively (Soos Creek Hatchery, Icy Creek Pond, Palmer Pond, Flaming Geyser Pond, Marine Technology Center, and Keta Creek Hatchery Complex); one uses only groundwater (Miller Creek Hatchery). The two net pens (Des Moines Marina Net Pens, and Elliott Bay Net Pens) only use marine water (passive use associated with tidal flows). The description of existing conditions for water quantity focuses on water quantity resources associated with the seven hatchery facilities that use fresh water where the action alternatives would occur. No water quantity effects are associated with the two net pen facilities.

A water right permit from Ecology is required for all surface water and groundwater withdrawals except, in many cases, those supporting single-family homes or other situations where a water right permit is not required. All water use by hatchery facilities supporting the seven existing salmon and steelhead programs is permitted by Ecology. Water available for use under water right permits are maximums. Water that is chronically unused by a permit holder is relinquished, meaning that the quantity of the water right is reduced.

Hatchery facilities are typically operated to vary water use throughout the year based on the fish species, fish sizes, and numbers of fish being produced, as well as the volume of water associated with the rearing facilities being used. Such variations are consistent with the terms of the applicable water right permits.

Surface flows fluctuate seasonally, based on snowmelt, rainfall levels and releases of water from Howard Hanson Dam, with flows generally highest in winter and spring. Water needs for the hatchery programs also fluctuate seasonally, with the highest hatchery water withdrawal needs occurring in the late winter and spring months because that is when fish are at their largest size and need high rearing flows to maintain fish health. Hatchery water withdrawal needs for fish rearing are lowest in the late summer months when river flows are at their lowest level. This is because the fish being reared at that time are small and require less water to maintain fish health than they do during the winter and spring months.

Stream gages are not available adjacent to hatchery points of diversion and return, and thus, surface flow data are not available from each hatchery location. For the analyses in this EIS, surrogate surface water source flow data have been used. Sources for surrogate flow data are from U.S. Geological Survey (USGS) stream gaging stations nearest to each facility, and for which discharges are available for a time period spanning at least 5 years. These flow data reflect the water in the streams at the locations of measurement. These water quantity data can also be found in Table 6.

Table 6. Water source and permitted maximum use at hatchery facilities that support seven existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin.

Hatchery Facility	Water Right Permit or Certificate	Maximum Daily Surface Water Use (cfs)	Maximum Daily Groundwater Use (cfs)	Water Source	Average Daily Discharge (min/mean/max) (cfs)[1]
Soos Creek Hatchery	S1-000382CL	NA[2]	0.71	Spring	Not known
	S1-000449CL	2.64	NA	Big Soos Creek	17/119/1,610[3]
	S1-21122CWRIS	5.0	NA		
	S1-*19055CWRIS	30.0	NA		
Miller Creek Hatchery	See footnote[4]	NA	Not known	Well	NA
Keta Creek Complex	S1-22989	NA	2.0	Spring	Not known
	S1-24508C	0.55	NA	Crisp Creek	Not known
	S1-22503C	8.0			
	S1-23839C	2.0			
Marine Technology Center	See footnote[5]	Not known	NA	Unnamed creek ("North Creek")[5]	Not known
Palmer Pond	S1-20296CWRIS	NA	15	Spring	0.89/not known/21.2[6]
Icy Creek Pond	S1-22710CWRIS	20.0	NA	Icy Creek	2.2/not known/13[7]
Flaming Geyser Pond	S1-24715CWRIS	1.5	NA	Cristy Creek	Not known

Sources: Water right permit and certificate numbers are from HGMPs (Muckleshoot Indian Tribe 2014a, 2014b, 2014c, 2014d; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014b, 2014c, 2015), where provided. Maximum daily surface and groundwater use levels are those permitted under water rights. Surface water sources are from the HGMPs.

[1] Average daily discharge data are from USGS stream gaging stations in the Duwamish-Green River Basin nearest to each facility, and reporting discharge for a period of record greater than 5 years; mean of mean daily flow, minimum of mean daily flow, maximum of mean daily flow for all months. Flow gaging stations are not available at each hatchery facility site. Gallons per minute (gpm) as stated in HGMPs are converted to cubic feet per second (cfs) using cfs = gpm/7.48/60; or 1 gpm = 0.0022 cfs]).

[2] NA = not applicable.

[3] Summary of USGS discharge record for Big Soos Creek streamflow monitoring station #12112600 for water years 2006-2015 (most recent 10 years). The gage is located just upstream of the Soos Creek Hatchery.

[4] Eggs and fish are reared on pathogen-free well water provided by the Southwest Suburban Sewer District Miller Creek water treatment plant; the District holds the water right.

[5] The water source for the Marine Technology Center hatchery facility is a small unnamed stream (no WRIA number; locally known as North Creek). North Creek surface water use is regulated under a water right permit deeded to the Puget Sound Skills Center through a lease from the City of Burien.

[6] Spring and stream system is not gaged; estimates of annual minimum and maximum flows are from WDFW (2015).

[7] Spring and stream system is not gaged; estimates of annual minimum and maximum flows are from WDFW (2013).

The following sections summarize withdrawals of fresh water at the facilities that support the salmon and steelhead hatchery programs in the Duwamish-Green River Basin.

Soos Creek Hatchery: The Soos Creek Hatchery uses surface water withdrawn from the Big Soos Creek and groundwater withdrawn from a spring. Four pumps withdraw water from Soos Creek, which is the primary water source. The spring water supply is used for incubation purposes. The hatchery withdraws up to 37.6 cfs from Big Soos Creek and up to 0.71 cfs from a local spring to support the Soos Creek fall-run Chinook salmon and Soos Creek coho salmon programs for adult holding, incubation, and rearing, as well as winter-run and summer-run steelhead programs for adult holding, incubation, and early rearing. Supplemental eggs and fry from the Soos Creek Hatchery may also be used by the Marine Technology Center coho salmon program. The Keta Creek Complex coho salmon program uses Soos Creek Hatchery coho production as a source of broodstock and fry. Monitoring and measurement of water usage is reported in monthly NPDES reports. All water (minus evaporation) is returned to Big Soos Creek after circulating through the hatchery. Water quantity within the stream is affected between the water intake and discharge structures. Water flows in Big Soos Creek average 119 cfs, with minimum flows of 17 cfs.

Miller Creek Hatchery: The Miller Creek Hatchery uses groundwater from a well owned by the Southwest Suburban Sewer District Miller Creek water treatment plant, which holds the water right for groundwater withdrawal. Outside of daily maintenance activities, no surface water is used. The hatchery withdraws water to support incubation and rearing for the Soos Creek coho salmon program. Withdrawal specific to hatchery use is unknown. Since onsite production at this facility does not meet the minimum threshold requiring an NPDES permit, the facility is not required to submit monthly reports of monitoring and measurement of water usage.

Keta Creek Hatchery Complex: The Keta Creek Hatchery and associated Crisp Creek Ponds use surface water withdrawn from Crisp Creek and groundwater withdrawn from a spring. Crisp Creek is fed by groundwater recharge and springs that discharge to the creek. The hatchery withdraws up to 10.6 cfs surface water from Crisp Creek and up to 2.0 cfs groundwater from a local spring. Water withdrawals at the hatchery support Keta Creek coho salmon and chum salmon programs for adult holding, incubation, and rearing. All water (minus evaporation) is returned to Crisp Creek after circulating through the hatchery. Water quantity at Crisp Creek is affected between the water intake and discharge structures. Water flows in Crisp Creek are unknown. The hatchery uses water consistent with its state water right permit. Monitoring and measurement of water usage is reported in monthly NPDES reports.

Marine Technology Center: The Marine Technology Center uses surface water from an unnamed creek (locally referred to as North Creek), which does not have known fish use. The hatchery withdraws water to support coho salmon incubation and rearing. All water (minus evaporation) is returned to North Creek after circulating through the hatchery. Water quantity is affected between the water intake and discharge structures in North Creek. The facility uses water consistent with the state water right permit deeded to the Puget Sound Skills Center through a lease from the City of Burien. Since onsite production at this facility does not meet the threshold requiring an NPDES permit, the facility is not required to submit monthly reports of monitoring and measurement of water usage. Water flows in North Creek are unknown.

Palmer Pond: Palmer Pond uses groundwater withdrawn from a spring. Up to 15 cfs is withdrawn to support Soos Creek fall-run Chinook salmon rearing and the Green River late winter-run steelhead program. Water flows in the spring range from 0.9 to 21 cfs based on estimates from WDFW (2013). Monitoring and measurement of water usage is reported in monthly NPDES reports. No listed or anadromous fish occur above the point of water withdrawal.

Icy Creek Pond: The Icy Creek Pond uses surface water withdrawn from Icy Creek. Up to 20.0 cfs are withdrawn on a daily basis. The pond uses water to support Soos Creek fall-run Chinook salmon and Green River winter-run steelhead rearing and acclimation, and Soos Creek summer-run steelhead rearing, acclimation, and release. Water flows from the spring range from 2.2 to 13 cfs based on estimates from WDFW (2013). All water (minus evaporation) is returned to Icy Creek after circulating through the hatchery. Water quantity is only affected between the water intake and discharge structures. Monitoring and measurement of water usage is reported in monthly NPDES reports. No listed or anadromous fish occur above the point of water withdrawal due to a steep gradient above the hatchery.

Flaming Geyser Pond: The Flaming Geyser Pond uses surface water from Cristy Creek. Up to 1.5 cfs is withdrawn on a daily basis. Water flows from Cristy Creek are unknown. All water (minus evaporation) is returned to Cristy Creek after circulating through the hatchery. Water quantity is affected between the water intake and discharge structures at Cristy Creek. The pond supports Green River late winter-run steelhead rearing and acclimation. Water use at the facility is consistent with its state water right permit. Since onsite production at this facility does not meet the threshold requiring an NPDES permit, the facility is not required to submit monthly reports of monitoring and measurement of water usage.

The two net pens (Des Moines Marina Net Pens and Elliott Bay Net Pens) passively use only tidally influenced marine water for operations and, thus, do not require water rights or certificates with maximum daily uses.

In summary, considering all effects on water quantity from the hatchery programs under existing conditions, the hatchery programs overall have had a low negative effect on water quantity in the Duwamish-Green River Basin. This is because maximum seasonal water use from the facilities associated with the seven hatchery programs (late winter and spring months) is non-consumptive, water is returned to watercourses near points of withdrawal, and the facilities comply with their state water right permits. No stream reaches are dewatered to the extent that migration and rearing of listed natural-origin fish are impaired and there is no net loss of river or tributary flow volume.

3.1.2 Water Quality

Water quality in the Duwamish-Green River Basin has been substantially affected by human-based disturbances resulting from urban development, especially in the lower reaches of the river basin (NMFS 2006; Shared Strategy for Puget Sound 2007; NWIFC 2016). For example, the lower Duwamish River has been listed under the Clean Water Act as a Superfund site since 2001. A proposed cleanup plan for the site was recently prepared (EPA 2013). Although habitat restoration efforts are ongoing, extensive development has reduced riparian vegetation and the stream shading it provides, which contributes to increased stream temperatures. In addition, development leads to increases in impervious surfaces such as roads, parking lots, and rooftops, which contribute storm water runoff that can negatively affect water quality.

Water quality parameters can be negatively affected by hatchery programs because water enters hatchery facilities used for fish production, receives inputs of fish, fish food, and pharmaceuticals used for fish health, and is then returned after use as effluent to the natural environment. Water quality parameters that can be altered by effluent include temperature, ammonia, organic nitrogen, total phosphorus, biochemical oxygen demand (BOD), pH, and solids levels (Subsection 3.6.1, Water Quality, in the PS Hatcheries DEIS [NMFS 2014a]). Hatchery facility effluents can also contain chemicals that are used to support hatchery production including antibiotics (a therapeutic), fungicides, disinfectants, pathogens, anesthetics, herbicides, and feed additives (Subsection 3.6.1, Water Quality, in the PS Hatcheries DEIS [NMFS 2014a]).

Discharge of hatchery effluents is regulated by EPA under the Clean Water Act through NPDES permits. For discharges from hatchery facilities not located on Federal or tribal lands, EPA has delegated its regulatory oversight to Washington State via Ecology. Washington State depends primarily on EPA to develop water quality standards. In addition, Indian tribes may adopt their own water quality standards for permits on tribal lands. Compliance by hatchery facilities with applicable Federal, state, and tribal regulations is described in Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance in the PS Hatcheries DEIS (NMFS 2014a).

Although existing hatchery facilities (including hatcheries, rearing ponds, acclimation ponds, and net pens), in general, are not identified as sources of water quality impairment to streams based on hatchery facility effluent discharges (Table 7), the effluent discharged from existing hatchery facilities contributes to the total pollutant load of receiving and downstream waters (PS Hatcheries DEIS [NMFS 2014a]). Periodic effluent permit limit exceedances of suspended and settleable solids also result in higher contributions to total pollutant loads, with the most common exceedances occurring for suspended solids that are typically one-time occurrences caused by high water flow events that flush influent sediments through the hatchery facility system (Subsection 3.6.1.2, Applicable Hatchery Facility Regulations and Compliance, in the PS Hatcheries DEIS [NMFS 2014a]). Salmon and steelhead carcasses are placed into streams after being spawned at hatchery facilities to increase beneficial marine-derived nutrients (nitrogen and phosphorus) (Subsection 3.2.3.8, Nutrient Cycling in the PS Hatcheries DEIS [NMFS 2014a]).

As part of administering elements of the Clean Water Act, Ecology is required to assess water quality in streams, rivers, and lakes. These assessments are published in 305(d) reports and 303(d) lists (the numbers referring to relevant sections of the Clean Water Act text). The 303(d) list identifies specific water bodies considered to be impaired, based on the number of exceedances of water quality criteria in a water body segment. In addition to the water bodies in Table 7 within the analysis area, the Duwamish-Green River is on the 303(d) list for a number impaired parameters (e.g., Duwamish River portion – temperature, pH, polychlorinated biphenyls (PCBs) (tissue), dichlorodiphenyltrichloroethane (DDT); Green River portion – dissolved oxygen) (Ecology 2015).

Table 7. Water quality permit compliance by hatchery facility and applicable 303(d) listed water bodies and impairments.

Hatchery Facility	Stream or River Source	Compliant with NPDES Permit?	Discharges Effluent into a 303(d) Listed Water Body?	Impaired Parameters	Cause of Impairment
Soos Creek Hatchery	Big Soos Creek (RM 0.6)	Yes	Yes	Dissolved oxygen, temperature, bioassessment[1]	Unknown
Miller Creek Hatchery	Miller Creek (RM 1)	NA	Yes	Dissolved oxygen, temperature, fecal coliform	Unknown
Keta Creek Complex	Crisp Creek (RM 1.1)	Yes	Yes	Dissolved oxygen, bioassessment	Unknown
Marine Technology Center	Unnamed Creek (North Creek)	NA	No	None	None
Palmer Pond	Unnamed Creek (RM 0.2)	Yes	No	None	None
Icy Creek Pond	Icy Creek (RM 0)	Yes	No	None	None
Flaming Geyser Pond	Cristy Creek (RM 0.1)	NA	No	None	None

Source: Ecology 2015

[1] Bioassessment = impairment of the biological community as measured using the River Invertebrate Classification System or Index of Biotic Integrity.

NA = Not applicable because the facility is not required to have an NPDES permit because the facility releases less than 20,000 pounds of fish per year or feeds fish less than 5,000 pounds of fish feed per year.

As described in Subsection 3.6.1, Water Quality, and Appendix J, Water Quality and Regulatory Compliance for Puget Sound Hatchery Facilities, in the PS Hatcheries DEIS (NMFS 2014a), which is incorporated by reference into this EIS, effects from operation of salmon and steelhead hatchery programs in the Puget Sound area, including the Duwamish-Green River Basin, on water quality under existing conditions are not substantial. Similar results were found in other NEPA analyses of hatchery programs in Puget Sound river basins (Subsection 3.3, Water Quality, in the Elwha FSEA [NMFS 2014b]; Subsection 3.3, Water Quality, in the Dungeness Hatcheries FEA [NMFS 2016a]; and Subsection 3.2, Water Quality, in the Hood Canal Hatcheries FEA [NMFS 2016b]). The effects of salmon and steelhead hatchery programs on water quality are not substantial primarily because all hatchery facilities reviewed would limit their pollutant discharges in accordance with their NPDES permits, or do not need a NPDES permit because they release less than 20,000 pounds of fish per year or feed fish less than 5,000 pounds of fish feed per year (i.e., they are not considered significant contributors of pollution). Additionally, all hatchery facilities are required to comply with applicable Federal, state, and tribal water quality and groundwater standards, as well as federal and state regulations for safe storage, handling, and application of chemicals and feed.

In summary, considering all effects on water quality from the seven hatchery programs under existing conditions, the hatchery programs overall have had a negligible negative effect on water quality in the Duwamish-Green River Basin, primarily because hatchery operations limit their pollutant discharges in accordance with their NPDES permits and do not contribute substantially to water quality impairments in the basin.

3.2 Salmon and Steelhead

This subsection describes existing conditions for salmon and steelhead that may be affected by the alternatives, specifically, changes in release numbers and hatchery program type. Information is provided on the general factors that affect the presence of these species, hatchery production in Puget Sound and its general effects on these species, and existing salmon and steelhead hatchery programs associated with the proposed Duwamish-Green River Basin salmon and steelhead hatchery programs. Additional information on salmon and steelhead in the analysis area and effects associated with Puget Sound hatchery programs can be found in Subsection 3.2, Fish, in the PS Hatcheries DEIS (NMFS 2014a).

Since 1999, NMFS has identified two salmon ESUs (Puget Sound Chinook Salmon and Hood Canal Summer Chum Salmon) and one steelhead DPS (Puget Sound Steelhead) in Puget Sound that require protection under the ESA (64 Fed. Reg. 14308, March 24, 1999; 70 Fed. Reg. 37160, June 28, 2005; 72 Fed. Reg. 26722, May 11, 2007; 76 Fed. Reg. 50488, August 5, 2011). However, Hood Canal summer-run chum salmon do not occur in the Duwamish-Green River Basin and will not be discussed further in this EIS. Critical habitat was designated for the Puget Sound Chinook Salmon ESU and Puget Sound Steelhead DPS (70 Fed. Reg. 52630, September 2, 2005; 81 Fed. Reg. 9252, February 24, 2016).

There are four additional non-listed salmon species in Puget Sound (coho salmon, fall-run chum salmon [chum salmon], pink salmon, and sockeye salmon), that also occur in the Duwamish-Green River Basin (Table 8). Critical habitat has not been designated for these species because they are not listed under the ESA. The sockeye salmon that occur in the Green River are of the river-run form, and their annual numbers are not substantial (Gustafson et al. 1997; Gustafson and Winans 1999). Thus, effects on sockeye salmon are not analyzed in Chapter 4, Environmental Consequences, in this EIS.

Table 8. Natural-origin salmon and steelhead populations occurring in the analysis area.

Species or Stock	Listing Status under ESA	Duwamish/ Green River Basin	Occurrence in Puget Sound Marine Areas
Spring/Summer-run Chinook Salmon[1]	Threatened		X
Fall-run Chinook Salmon	Threatened	X	X
Winter-run Steelhead[2]	Threatened	X	X
Summer-run Steelhead	Threatened		X
Coho Salmon	Not listed	X	X
Chum Salmon	Not listed	X	X
Pink Salmon	Not listed	X[3]	X
Sockeye Salmon	Not listed	X[4]	X

[1] Spring-run Chinook salmon are considered to be extinct in the Duwamish-Green River Basin (Ruckelshaus et al. 2006).

[2] Populations of steelhead in the Puget Sound DPS include both summer- and winter-run life history types; however, the DPS is composed primarily of winter-run populations (Myers et al. 2015).

[3] Washington Department of Fisheries et al. (1993) and Hard et al. (1996) noted pink salmon were rare in the Green River. However, substantial returns have occurred in recent years (Topping et al. 2009).

[4] The sockeye salmon that occur in the Green River are of the river-run form, and their annual numbers are not substantial (Gustafson et al. 1997; Gustafson and Winans 1999). Thus, effects on sockeye salmon are not analyzed in this EIS.

The analysis area for salmon and steelhead includes the geographic area where the Proposed Action would occur (Subsection 1.4, Project and Analysis Areas) and includes marine areas of Puget Sound (Subsection 1.4, Project and Analysis Areas) where hatchery-origin juveniles from the Duwamish-Green River Basin initially forage and congregate prior to moving to the ocean. Table 8 summarizes the salmon and steelhead species that occur in the analysis area.

3.2.1 General Factors that Affect the Presence and Abundance of Salmon and Steelhead

Subsection 3.2, Salmon and Steelhead, is focused on the effects of the seven existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin on listed and non-listed salmon and steelhead in the analysis area; however it is important to recognize that these hatchery programs are but one of a variety of natural and human-caused changes that have and will continue to affect these species. Some of these changes are briefly described below. These changes have affected the abundance, productivity, diversity, and distribution of salmon and steelhead in Puget Sound. In addition to hatchery programs, NMFS salmon status reviews (Myers et al. 1998; Good et al. 2005;

Ford 2011; Northwest Fisheries Science Center [NWFSC] 2015), recovery plans (72 Fed. Reg. 2493, January 19, 2007; 72 Fed. Reg. 29121, May 24, 2007), and other documents (Washington State Conservation Commission 2005; RCO 2016; NWIFC 2016) describe a range of past and current factors that contributed to the decline of salmon and steelhead in Puget Sound, including:

Habitat: Freshwater and marine habitats have been modified from development and land use practices related to agriculture, forestry, industry, and residential use. In streams, these modifications have altered stream hydrology and natural stream channels, reduced riparian cover and large woody debris, increased sedimentation, affected water quantity (higher and lower stream flows), degraded water and sediment quality, and increased flooding. In marine areas, these modifications have altered shorelines and reduced the physical and ecological complexity of estuarine areas (sometimes completely). These modifications have compromised areas used by salmon and steelhead for feeding, migration, and rearing.

Dams and Diversions: Construction of dams, water diversion structures, and hydroelectric operations can block salmon and steelhead migration routes, entrain (trap) migrating juveniles, change stream flow patterns, and alter natural water temperature regimes.

Predation: Direct and indirect[6] predation by native and introduced aquatic, terrestrial, and avian species result in salmon and steelhead mortality.

Ocean Conditions: Broad-scale, cyclic changes in climatic and ocean conditions drive salmon and steelhead productivity (e.g., El Niño events), and may produce density-dependent[7] effects that are important to how and where populations of salmon and steelhead are sustained over the short and long term (e.g., Independent Scientific Advisory Board [ISAB] 2015; NWFSC 2015).

Climate Change: Changes in the climate can alter the abundance, productivity, and distribution of salmon and steelhead through changes in water temperatures and seasonal stream flow regimes, which then affect the type and extent of aquatic habitat that is suitable for viable salmon and steelhead (NWFSC 2015).

[6] Direct predation occurs when a fish is directly consumed by a predator. Indirect predation occurs when a fish is consumed due to attraction of predators to prey, and can result from hatchery-origin salmon and steelhead releases.

[7] In population ecology, density-dependent processes occur when population growth rates are controlled by the density of a population. Usually, the denser a population is, the greater its mortality. Most density-dependent factors are biological in nature, such as predation and competition.

These changes are described in more detail in Subsection 3.2.2, General Factors that Affect the Presence and Abundance of Salmon and Steelhead, in the PS Hatcheries DEIS (NMFS 2014a).

In a review of these and other factors, NMFS concluded that the impacts to salmon and steelhead habitat and health continue to suppress prospects for recovery of listed natural-origin salmon and steelhead, including current and continuing degradation and loss of habitat essential for their survival and productivity (NMFS 2011a). All of the past and current factors described above have negatively affected salmon and steelhead populations, distribution, and overall survival.

The most recent 5-year status review for the Puget Sound Chinook Salmon ESU (NWFSC 2015) found that the biological risks faced by the ESU have not substantively changed since the species was listed, or since the last status review (Ford 2011). The populations comprising the ESU remain well below the goals or planning ranges in the Puget Sound Chinook salmon recovery plan (NMFS 2006). Hatchery-origin spawners are present in high percentages in most populations outside of the Skagit River watershed, and in many watersheds the percentages of spawner abundances of natural-origin declined over time (NWFSC 2015). Overall, the most recent information on viability, including abundance, productivity, spatial structure, and diversity, does not indicate a change in the biological risk category from threatened for the Puget Sound Chinook Salmon ESU (NWFSC 2015).

The most recent 5-year status review for the Puget Sound Steelhead DPS (NWFSC 2015) found that the biological risks associated with populations within this DPS have not substantively changed since its listing in 2007, or since its last status review (Ford 2011). NWFSC (2015) also noted that during the two most recent years evaluated, temperatures of marine waters and streams were especially warm and thus, unfavorable for high marine or freshwater survival. Using various methods, NWFSC (2015) reviewed the viability (abundance, productivity, diversity, and spatial structure) of the Puget Sound Steelhead DPS and its component population groups and individual populations and found that none of the natural-origin populations in the DPS, including the Green River population, is currently viable.

3.2.2 Salmon and Steelhead Hatchery Programs

3.2.2.1 General Effects of Puget Sound Salmon and Steelhead Hatchery Programs

Hatchery programs for salmon and steelhead have the potential to negatively affect natural-origin salmon and steelhead and their habitat through genetic risks, competition and predation, hatchery facility effects, incidental fishing effects, and disease transfer. The PS Hatcheries DEIS (NMFS 2014a) describes in more detail these general mechanisms, and is incorporated by reference (Subsection 1.1.3, Related National Environmental Policy Act Reviews) in this EIS.

Based on a review of 90 hatchery plans submitted to NMFS, the co-managers currently release about 167 million juvenile hatchery-origin salmon and steelhead into Puget Sound freshwater and marine areas each year, including 50.0 million Chinook salmon, 15.3 million coho salmon, 54.1 million chum salmon, 4.1 million pink salmon, 42.3 million sockeye salmon, and 1.2 million steelhead (Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities). This total current release level is somewhat higher but similar to the total Puget Sound production level of 147 million salmon and steelhead that was analyzed in the PS Hatcheries DEIS (NMFS 2014a).

Because of these similar release totals, the PS Hatcheries DEIS (NMFS 2014a) provides a useful reference describing effects of hatchery production under existing conditions. To the extent that effects identified in the PS Hatcheries DEIS (NMFS 2014a) are greater because the hatchery production levels for some species analyzed were higher than current levels, the existing conditions used in the PS Hatcheries DEIS (NMFS 2014a) support a risk-averse context from which to evaluate the alternatives in this EIS. To the extent that the effects described in PS Hatcheries DEIS (NMFS 2014a) are less because levels for some species were substantially lower than current levels, the effects from existing conditions as described in the PS Hatcheries DEIS (NMFS 2014a) may underestimate current levels of effects.

The PS Hatcheries DEIS (NMFS 2014a) describes effects based on production levels of 45.3 million Chinook salmon, 14.6 million coho salmon, 45.0 million fall-run chum salmon, 4.5 million pink salmon, 35.1 million sockeye salmon, and 2.5 million steelhead (Table 2.4-1 in PS Hatcheries DEIS [NMFS 2014a]). Since the publication of that DEIS, the co-managers have changed production levels in some hatchery programs. Table 9 shows the production levels analyzed in the PS Hatcheries DEIS (NMFS 2014a) and in this EIS (Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities).

Table 9. Annual juvenile salmon and steelhead hatchery production (in thousands) as described in the PS Hatcheries DEIS (NMFS 2014a) and in Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities, of this EIS.

Species	Puget Sound Hatcheries DEIS (% of total)	Appendix A (% of total)
Chinook Salmon	45,317 (31)	50,013 (30)
Coho Salmon	14,592 (10)	15,322 (9)
Steelhead	2,468 (2)	1,200 (1)
Chum Salmon	44,995 (30)	54,125 (32)
Pink Salmon	4,500 (3)	4,100 (3)
Sockeye Salmon	35,125 (24)	42,340 (25)
Total	146,997 (100)	167,100 (100)

With two exceptions (lower levels of steelhead and pink salmon releases) current hatchery release levels are similar to or higher than those analyzed in the PS Hatcheries DEIS (NMFS 2014a). Current releases of Chinook salmon are higher (by 4.7 million fish, or 10 percent) than those analyzed in the PS Hatcheries DEIS (NMFS 2014a) primarily because of increases from the Skookum Creek, Samish, and Soos Creek hatchery programs. Current releases of coho salmon are slightly higher (by 730,000 smolts, or 5 percent) than those analyzed in the PS Hatcheries DEIS (NMFS 2014a), as various programs were modified, reduced, increased, or terminated. Current releases of chum salmon are higher (by 9.1 million fish, or 20 percent) than those analyzed in the PS Hatcheries DEIS (NMFS 2014a) primarily because of increases from the North Fork Nooksack, Lummi Bay, Keta Creek, and McKernan hatchery programs. Current releases of sockeye salmon are higher (by 7.2 million fish, or 20 percent) than those analyzed in the PS Hatcheries DEIS (NMFS 2014a), because of increases in one of the two sockeye salmon programs in the analysis area – Baker River. Lower release levels for steelhead (by 1.3 million fish, or 51 percent) and pink salmon (by 400,000 fish, or 9 percent) are due primarily to program terminations and reductions, respectively, relative to those analyzed in the PS Hatcheries DEIS (NMFS 2014a).

In Puget Sound, run size and escapement monitoring from 2005 to 2009 indicates that returns of hatchery-origin fish constitute 76 percent of adult Chinook salmon returns, 47 percent of coho salmon returns, 29 percent of fall-run chum salmon returns, 30 percent of sockeye salmon returns, 2 percent of pink salmon returns, and an unknown proportion of steelhead returns (PS Hatcheries DEIS [NMFS 2014a]).

Hatchery programs can affect natural-origin salmon and steelhead and their habitat through a variety of general mechanisms (Table 10). These mechanisms and effects are also described in Chapter 3, Affected Environment, and Appendix B, Hatchery Effects and Evaluation Methods for Fish, Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, and Appendix H, Steelhead Effects Analysis by Basin, in the PS Hatcheries DEIS (NMFS 2014a). The extent of effects can be negative or positive, depending on the objectives and design of hatchery programs, the condition of the habitat, and the status of the species, among other factors.

3.2.2.2 Existing Conditions and Effects of Current Salmon and Steelhead Hatchery Programs in Puget Sound

This subsection provides a summary of the affected environment associated with effects of hatchery programs described in the PS Hatcheries DEIS (NMFS 2014a) that is incorporated by reference into this EIS, and also considers the effects of changes in salmon and steelhead release levels that have occurred since the PS Hatcheries DEIS (NMFS 2014a) was prepared. In the PS Hatcheries DEIS (NMFS 2014a), the No-action Alternative identified potential effects on listed and non-listed salmon and steelhead species in Puget Sound from the total number of salmon and winter-run and summer-run steelhead released into Puget Sound fresh and marine waters at the time of the analysis (Alternative 1 in Table S-4 in PS Hatcheries DEIS (NMFS 2014a).

As described in Subsection 2.1.1.2, Competition – Estuarine and Marine Areas, and Subsection 2.1.2.2, Predation – Estuarine and Marine Areas, in Appendix B of the PS Hatcheries DEIS (NMFS 2104a), competition and predation from hatchery-origin salmon and steelhead juveniles in estuarine and marine areas can lead to negative impacts on natural-origin fish. Negative impacts on natural-origin fish from competition would be expected to be greatest where preferred food may be limiting (Species Interactions Work Group [SIWG] 1984). In the early marine life stages, when natural-origin fish enter marine waters and fish are concentrated in relatively small areas, food may be in short supply, and competition is most likely to occur. This period is of especially high concern when hatchery-origin chum salmon and pink salmon compete with natural-origin chum salmon and pink salmon for food resources.

Table 10. General mechanisms through which hatchery programs can affect natural-origin salmon and steelhead populations.

Effect Category	Description of Effect
Genetics	• Interbreeding with hatchery-origin fish can change the genetic character of the local populations. • Interbreeding with hatchery-origin fish may reduce the reproductive performance of the local populations.
Competition and Predation	• Hatchery-origin fish can increase competition for food and space. • Hatchery-origin fish can increase predation on natural-origin salmon and steelhead.
Facility Operations	• Hatchery facilities can reduce water quantity or quality in adjacent streams through water withdrawal and discharge. • Weirs for broodstock collection or to control the number of hatchery-origin fish on the spawning grounds can have the following unintentional consequences: o Isolation of formerly connected populations o Limiting or slowing movement of migrating fish species, which may enable poaching or increase predation o Alteration of stream flow o Alteration of streambed and riparian habitat o Alteration of the distribution of spawning within a population o Increased mortality or stress due to capture and handling o Impingement of downstream migrating fish o Forced downstream spawning by fish that do not pass through the weir o Increased straying due to either trapping adults that were not intending to spawn above the weir, or displacing adults into other tributaries
Masking	• Hatchery-origin fish can increase the difficulty in determining the status of the natural-origin component of a salmon or steelhead population.
Incidental Fishing	• Fisheries targeting hatchery-origin fish have incidental impacts on natural-origin fish.
Disease	• Concentrating salmon and steelhead for rearing in a hatchery facility can lead to an increased risk of carrying fish disease pathogens. When hatchery-origin fish are released from the hatchery facilities, they may increase the disease risk to natural-origin salmon and steelhead through pathogen transmission.
Population Viability Benefits	• Abundance: Preservation of, and possible increases in, the abundance of a natural-origin fish population resulting from implementation of a hatchery program. • Spatial Structure: Preservation or expansion of the spatial structure of a natural-origin fish population resulting from implementation of a hatchery program. • Genetic Diversity: Retention of within-population genetic diversity of a natural-origin fish population resulting from implementation of a hatchery program. • Productivity: Maintenance of or increase in the productivity of a natural-origin fish population from implementation of a hatchery program, if naturally spawning hatchery-origin fish match natural-origin fish in reproductive fitness and the natural-origin population's abundance is low enough to limit the productivity of the natural-origin fish (i.e., they are having difficulty finding mates).
Nutrient Cycling	• Returning hatchery-origin adults can increase the amount of marine-derived nutrients in freshwater systems.

Predation risks in marine waters are greatest to natural-origin pink salmon, chum salmon, and sockeye salmon from releases of yearling hatchery-origin coho salmon, Chinook salmon, and steelhead (SIWG 1984). Of all the hatchery-origin fish released, the larger Chinook salmon, coho salmon, and steelhead that are released at the yearling life stage have the greatest potential to be predators, and the smaller natural-origin pink salmon, chum salmon, and sockeye salmon have the greatest potential to be prey (Subsection 2.1.2.2, Predation – Estuarine and Marine Areas, in Appendix B of the PS Hatcheries DEIS [(NMFS 2104a]).

For the listed Puget Sound Chinook Salmon ESU, the PS Hatcheries DEIS (NMFS 2014a) found overall salmon and steelhead production poses a low to high risk and low to moderate benefit (Table 3.2-10 in the PS Hatcheries DEIS [NMFS 2014a]). Specifically, competition risk in fresh water is moderate, predation risk in fresh water (direct and indirect) is high, genetic risk is moderate, and hatchery facilities risk (including disease transfer) is low (Table 3.2-10 in the PS Hatcheries DEIS [NMFS 2014a]). Similarly, total salmon and steelhead production poses a moderate benefit and low viability benefit to the listed Puget Sound Chinook Salmon ESU. The relatively small increase (5 percent) in the current Chinook salmon release level would be unlikely to substantially change the effects on the Puget Sound Chinook Salmon ESU from those described in the PS Hatcheries DEIS (NMFS 2014a).

For the listed Puget Sound Steelhead DPS, the PS Hatcheries DEIS (NMFS 2014a) found overall salmon and steelhead production poses a moderate risk and low benefit (Table 3.2-16 in the PS Hatcheries DEIS [NMFS 2014a]). For the steelhead DPS overall, competition risk is moderate, genetic risk is low, and hatchery facilities risk (including disease transfer) is low (PS Hatcheries DEIS [NMFS 2014a]). These effects would be expected to be lower under current conditions because steelhead releases have decreased 53 percent from the levels analyzed in the PS Hatcheries DEIS (NMFS 2014a).

For non-listed natural-origin salmon species (coho salmon, chum salmon, pink salmon, and sockeye salmon) in the analysis area, the analyses in the PS Hatcheries DEIS (NMFS 2014a) found overall salmon and steelhead production poses competition, predation (direct and indirect), genetics, and hatchery facilities and operation risks (Alternative 1 in Table S-4 in the PS Hatcheries DEIS [NMFS 2014a]).

As described in Subsection 4.2.8.3, Risks and Benefits (Coho Salmon) in the PS Hatcheries DEIS (NMFS 2014a), yearling releases of coho salmon, Chinook salmon, and steelhead pose the greatest risk to coho salmon in fresh water from competition and predation, and genetic risks occur when hatchery-origin coho salmon that have been affected by hatchery-influenced selection stray into and spawn with natural-origin coho salmon in natural spawning areas. Hatchery operations risks are not substantial.

As described in Subsection 4.2.9.3, Risks and Benefits (Fall-run Chum Salmon) in the PS Hatcheries DEIS (NMFS 2014a), releases of pink salmon and chum salmon pose competition risks to chum salmon in marine areas due to their similar size and spatial and temporal overlap. Predation risks to fall-run chum salmon are greatest in fresh water (and are possible in marine waters) from the larger yearling hatchery-origin Chinook salmon and coho salmon when they overlap in space and time with the smaller fall-run chum. Hatchery operations risks are not substantial.

As described in Subsection 4.2.10.3, Risks and Benefits (Pink Salmon) in the PS Hatcheries DEIS (NMFS 2014a), risks to natural-origin pink salmon from hatchery-origin fish occur primarily from competition with similar-sized hatchery-origin chum salmon in fresh water and adjacent marine waters, and from predation by larger hatchery-origin steelhead, yearling coho salmon, and subyearling and yearling Chinook salmon in fresh water and marine waters. Hatchery operations risks to pink salmon are negligible because there are few pink salmon hatchery programs in the analysis area.

As described in Subsection 4.2.11.3, Risks and Benefits (Sockeye Salmon) in the PS Hatcheries DEIS (NMFS 2014a), releases of hatchery-origin coho salmon yearlings have the greatest potential to affect similarly sized natural-origin sockeye salmon through competition in marine areas and in rivers and streams below lakes used by juvenile sockeye salmon for migration to marine areas. In addition, releases of larger hatchery-origin steelhead have the greatest potential to impact smaller natural-origin sockeye salmon through predation in fresh water (in waters below lakes used by juvenile sockeye salmon for migration to marine areas). Hatchery operations risks to sockeye salmon are negligible because there are few sockeye salmon hatchery programs in the analysis area. As discussed in Subsection 3.2, Salmon and Steelhead (Introduction), the sockeye salmon that occur in the Green River are of the river-run form, and their annual numbers are not substantial. Thus, effects on sockeye salmon are not analyzed in Chapter 4, Environmental Consequences, in this EIS.

3.2.2.3 Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin

As shown in Table 3, seven salmon and steelhead hatchery programs currently operate in the Duwamish-Green River Basin and annually release up to 12,443,000 juvenile salmon and steelhead, as follows:

- Soos Creek fall-run Chinook salmon program - 4,200,000 subyearlings and 300,000 yearlings
- Green River late winter-run steelhead program - 33,000 yearlings

- Soos Creek summer-run steelhead program - 100,000 yearlings
- Soos Creek, Keta Creek, and Marine Technology Center coho salmon programs – 2,690,000 yearlings and 120,000 fry
- Keta Creek chum salmon program – 5,000,000 fry

In addition, there are three hatchery programs that do not yet operate but are part of the Proposed Action (Subsection 1.2, Description of the Proposed Action). These are the FRF fall-run Chinook salmon (Muckleshoot Indian Tribe 2014d), FRF late winter-run steelhead (Muckleshoot Indian Tribe 2014a), and FRF coho salmon (Muckleshoot Indian Tribe 2014c) hatchery programs. These three programs together would produce up to 1,550,000 fish annually (Table 3), and are analyzed in this EIS in Chapter 4, Environmental Consequences.

There are two types of hatchery programs operating in the Duwamish-Green River Basin. Of the seven programs, five are operated as integrated programs, and two are operated as isolated programs (Table 3). In integrated hatchery programs, the hatchery-origin populations are reproductively integrated with the natural-origin population, in particular by using local fish for broodstock and other practices. These programs produce fish that are similar to local populations and may be listed under the ESA, and may augment the abundance of natural-origin spawners and contribute to the population viability or recovery of listed salmon ESUs or steelhead DPSs. Integrated hatchery programs can have harvest/and or conservation management objectives. Under existing conditions, four of the five integrated hatchery programs in the Duwamish-Green River Basin have harvest objectives, and one program (Green River late winter-run steelhead) has conservation as its objective.

In isolated hatchery programs (sometimes also called segregated programs), the hatchery-origin populations are reproductively segregated from the natural-origin population, in particular by using only hatchery-origin fish for broodstock and other practices. These programs produce fish that are different from local populations and typically are not listed under the ESA. The programs do not augment the abundance of natural spawners or contribute to the population viability or recovery of listed salmon ESUs or steelhead DPSs; the programs are designed to contribute to harvest while minimizing negative impacts on natural-origin populations.

Below are short summaries of the seven existing hatchery programs organized by species, noting program background, type, and management objectives. In general, more information is available for listed species (Chinook salmon and steelhead) than unlisted species (coho salmon, chum salmon, and pink salmon).

Chinook Salmon

There is currently one fall-run Chinook salmon hatchery program operating in the Duwamish-Green River Basin. Operating as an integrated program, the Soos Creek Hatchery fall-run Chinook salmon program originated from broodstock collected from the mainstem Green River from 1901 through 1924 (Becker 1967). After 1924, sufficient adult returns to the hatchery release site had been established to create a self-sustaining program (Becker 1967). These fall-run Chinook salmon of Green River lineage are considered to be the only existing Chinook salmon population in the Duwamish-Green River Basin, which includes all hatchery-origin and natural-origin fall-run Chinook salmon. The spring-run life history form is considered to be extinct in the Duwamish-Green River Basin (Ruckelshaus et al. 2006). Fish from the Soos Creek fall-run Chinook salmon hatchery program are not genetically distinct from natural-origin fall-run Chinook salmon that currently spawn naturally in the Green River (Jones 2006). The fish produced by the hatchery program are part of the listed Puget Sound Chinook Salmon ESU. The purpose of the program is to provide harvest opportunities while supporting conservation and population recovery goals (WDFW 2013).

Steelhead

There are currently two steelhead hatchery programs operating in the Duwamish-Green River Basin: the Green River late winter-run steelhead program, and the Soos Creek early summer-run steelhead program[8].

Green River late winter-run steelhead – The Green River late winter-run program was initiated in 2001. It is an integrated conservation program that uses natural-origin adults collected from the mainstem of the Green River that represent the genetic diversity of the natural-origin Green River steelhead population. The purpose of the program is conservation and recovery. The fish produced by the hatchery program are part of the listed Puget Sound Steelhead DPS.

Development of hatchery-origin winter-run steelhead within Puget Sound involved a long period of selective breeding to create fish that returned earlier than the original natural-origin winter-run

[8] Hatchery-origin winter-run steelhead are typically grouped into late and early types, depending on their timing of return to fresh water for spawning. Early winter steelhead and early summer steelhead return to and spawn earlier than their natural-origin counterparts. Broodstock for production of early steelhead are derived from non-local sources (e.g., winter-run are from Chambers Creek stock, and summer-run are from Skamania stock), and fish cultural practices over time (i.e., hatchery-influenced selection, sometimes called domestication) has created fish that return and spawn earlier than the natural-origin fish. Late winter steelhead are derived from local broodstock, and their return and spawn timing is more similar to the local natural-origin winter-run steelhead.

steelhead. These fish are referred to as early winter-run steelhead (early winter steelhead) or Chambers Creek stock. Hatchery releases of these early winter steelhead occurred in the Green River watershed starting in the 1930s for the purpose of producing fish for harvest. The early winter steelhead program operating at the Soos Creek Hatchery since 2002 has not been operating since 2015 (Final Environmental Impact Statement to Analyze Impacts of NOAA's National Marine Fisheries Service Proposed 4(d) Determination under Limit 6 for Five Early Winter Steelhead hatchery Programs in Puget Sound, [herein referred to as EWS Hatcheries FEIS (NMFS 2016c)]) (81 Fed. Reg. 12898, March 11, 2016.

Soos Creek summer-run steelhead – The Soos Creek summer-run steelhead program is an isolated program derived from broodstock from the Skamania Hatchery located on the Washougal River, a tributary of the lower Columbia River in the Lower Columbia River Steelhead DPS. This early summer-run steelhead program originated in 1960. The summer-run steelhead produced by the program are not native to the Duwamish-Green River Basin, did not originate from within the Puget Sound Steelhead DPS, and have been subjected to considerable hatchery-influenced selection over time. The purpose of the program is to provide harvest opportunities. Fish from this program do not contribute to the conservation or recovery of the listed Green River steelhead population. There are no known naturally occurring summer-run steelhead within the Duwamish-Green River Basin (Myers et al. 2015).

Coho Salmon

There are currently three coho salmon hatchery programs operating in the Duwamish-Green River Basin (Soos Creek, Keta Creek, and Marine Technology Center), two of which involve net pen rearing and/or releases of fish directly into marine waters.

Soos Creek coho salmon – Operating as an integrated program, the Soos Creek Hatchery coho salmon program was initiated in 1901 with adults collected locally from the Green River and Soos Creek. Although additional stocks were occasionally imported in the early days of the hatchery's operation, their contribution is not believed to be significant and the hatchery stock has remained, to a very large extent, similar to local natural-origin Soos Creek fish. The program has been maintained by adult returns to the hatchery for many decades (HSRG 2004). The program uses a number of release sites (e.g., Green River, net pens, and several small creeks such as Miller Creek and Walker Creek) that are independent tributaries to Puget Sound. Coho salmon juveniles from the Soos Creek Hatchery are also used for the Keta Creek coho salmon program. The Muckleshoot Indian Tribe currently uses these hatchery-origin fish to supplement releases from the Crisp Creek rearing ponds and the Elliott Bay net pens. The purpose of the Soos Creek coho salmon program is primarily to provide adult fish for harvest, while minimizing adverse effects on listed species.

Keta Creek coho salmon – Operating as an integrated program, the Keta Creek coho salmon program was initiated in 1975, when the WDFW began rearing coho salmon at Crisp Creek rearing ponds using juveniles transferred from the Soos Creek Hatchery. Nearly all coho salmon juveniles produced by the Keta Creek coho salmon program, including fish transferred to the program from the Soos Creek Hatchery, originated from broodstock local to the Green River. Additional stocks were occasionally imported in the early days of hatchery operation at the Soos Creek Hatchery, but their contribution was not significant. Broodstock for this program are currently collected at the Soos Creek Hatchery, the Keta Creek Complex, and a small proportion from the Tacoma Water headworks trap. Some fish are transferred for release to the Elliott Bay net pens. The purpose of the Keta Creek coho salmon program is primarily to provide adult fish for harvest, while minimizing adverse effects on listed species.

Marine Technology Center coho salmon – Operating as an isolated program, the Marine Technology Center coho salmon program began in 1970 using broodstock of Green River origin. Program facilities are located at the Marine Technology Center in Seahurst Park on the Puget Sound shoreline near Burien. The program releases juvenile coho salmon directly into Puget Sound. There are no natural-origin coho salmon populations in or adjacent to the area where releases occur. Supplemental eggs and fry may be provided by the Soos Creek Hatchery, the original broodstock source from which the program was initiated. Current broodstock are obtained from adult hatchery-origin returns to the hatchery trap near the facility. The primary purpose of the program is to provide an educational opportunity for a vocational program at Highline High School with harvest as a secondary objective.

Chum Salmon

There is currently one chum salmon hatchery program operating in the Duwamish-Green River Basin. Operating as an integrated program, the Keta Creek chum salmon program originated in 1975 using eggs from chum salmon provided by the USFWS Quilcene National Hatchery, and later from the Hoodsport Hatchery, both of which are located on Hood Canal. In 1990, the Keta Creek chum salmon program started using eggs from chum salmon broodstock from east Kitsap County in mid-Puget Sound, and use of broodstock of Hood Canal origin was discontinued. The mid-Sound chum salmon stock from east Kitsap County was the most locally available stock. Since 1996, the program has obtained hatchery-origin broodstock that return locally to Crisp Creek, where the hatchery-origin juveniles are released. The purpose of the program is primarily to provide adult fish for harvest, while minimizing adverse effects on listed species.

3.2.3 Effects of Current Duwamish-Green River Basin Hatchery Programs on Salmon and Steelhead

The affected environment associated with the past and current operation of the seven existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin is discussed in Subsection 3.2.3.1, Genetics, through Subsection 3.2.3.8, Nutrient Cycling.

Monitoring provides key information that is important for the operation of the hatchery programs and for improved understanding the status of natural-origin and hatchery-origin salmon and steelhead. As described in Subsection 1.5.3, NMFS's Determination as to Compliance with the 4(d) Rule, NMFS would require monitoring and evaluation as a condition of its approval of the HGMPs under the 4(d) Rule. Monitoring of the "viable salmonid population" (VSP) (McElhany et al. 2000) status of listed populations would be an important component of recovery plan and HGMP implementation. Existing monitoring activities that typically require sampling and handling of fish include, but are not limited to, obtaining information on smolt-to-adult survival, fishery contribution, natural-origin and hatchery-origin spawning abundance, juvenile out-migrant abundance and diversity, genetics (DNA) and gene flow (e.g., Anderson et al. 2014), and juvenile and adult fish health when the fish are in the hatchery. Monitoring activities typically use standard procedures to address potential impacts (Johnson et al. 2007). In addition, monitoring activities are conducted under separate approvals under the ESA, which minimize impacts to listed species. Thus under existing conditions, monitoring overall has had a negligible negative effect on natural-origin salmon and steelhead, because sampling and handling of natural-origin fish that is required to monitor their status are carefully implemented to minimize risks.

3.2.3.1 Genetics

Hatchery programs can have a variety of genetic effects on natural-origin salmon and steelhead. This analysis addresses the existing conditions associated with three major types of genetic risks from hatchery programs: within-population genetic diversity effects, outbreeding effects, and hatchery-influenced selection effects. Detailed information on genetic risks of Puget Sound hatchery programs is described in Subsection 2.1.3, Genetics, and Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a). Information on genetic risks associated with early winter steelhead and summer-run steelhead hatchery programs is described in Subsection 3.2.3, Effects of Current Early Winter Steelhead Hatchery Programs on Salmon and Steelhead, and Appendix B, Genetic Effects

Analysis of Early Winter Steelhead Programs Proposed for the Nooksack, Stillaguamish, Dungeness, Skykomish, and Snoqualmie River Basins of Washington, in the EWS Hatcheries FEIS (NMFS 2016c).

Genetic differences among natural-origin salmon and steelhead populations arise as a natural consequence of their homing tendencies. Adult salmon and steelhead return with high fidelity to the streams of their birth. This leads to a relatively high degree of genetic separation among populations and to differences that are beneficial to fish survival in their dynamic local environments. Some salmon and steelhead return to and spawn in streams other than their home streams, a process called straying, despite the strong tendency of salmon and steelhead to return to streams of their birth. If strays successfully reproduce, this results in gene flow. Straying is common in salmon and steelhead but varies in pattern and intensity (Quinn 1993), including hatchery-origin fish (Westley et al. 2013). Straying is thought to serve a useful purpose in nature by providing opportunities for species to naturally colonize or re-colonize vacant habitat. Straying is generally not beneficial when it results in gene flow from unnatural sources or occurs at unnatural levels, and can lead to loss of genetic diversity between populations and outbreeding depression.

Within-population Genetic Diversity: Genetic diversity is the suite of traits that allows populations to survive and adapt in response to environmental change. 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 and is lost primarily due to genetic drift, a random loss of diversity due to (small) population size. Some hatchery stocks have less genetic diversity and higher rates of genetic drift than naturally produced populations, presumably as a result of the small number of spawners that may have been used at hatcheries (Waples et al. 1990). By maximizing the number of adults used for broodstock, balancing sex ratios, and maintaining age structures, the loss of within-population diversity due to artificial propagation can be minimized. Hatchery broodstocks ideally would represent the variation in run timing, age composition, size, and fecundity that is observed in local natural-origin populations.

Outbreeding: Outbreeding effects are caused by gene flow from other populations and can reduce the fitness (i.e., survival) of populations in the first or subsequent generations after interbreeding. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993, 1997). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat. Straying is considered a risk only when it occurs at unnatural levels or from unnatural sources. Gene flow from other populations can have two effects: it can increase genetic diversity (Ayllon et al. 2006), 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-origin population and the recipient natural-origin population, the greater the genetic difference between the two populations (Interior Columbia Technical Recovery Team 2007), and the greater potential for outbreeding depression. Hatchery-origin fish from distant sources may, therefore, pose a greater risk to the genetic diversity of a local natural-origin population than hatchery-origin fish originating from the same local natural-origin population.

Hatchery-influenced selection: Hatchery-influenced selection occurs when selection pressures imposed by spawning and rearing practices under hatchery conditions differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural-origin populations through interbreeding with hatchery-origin fish, typically from the same population. 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 inadvertent selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999). Various studies have examined the effects of hatchery-influenced selection on salmon and steelhead. Species that are reared in hatcheries for a relatively short amount of time (e.g., subyearling Chinook salmon, chum salmon, and pink salmon) are less likely to be genetically changed by hatchery rearing than species with longer freshwater hatchery rearing times (e.g., coho salmon, yearling Chinook salmon, and steelhead) (Berejikian and Ford 2004).

The primary overarching concerns associated with the genetic risks described above (loss of within-population genetic diversity, outbreeding, and hatchery-influenced selection) are loss of fitness and productivity associated with interbreeding between hatchery-origin and natural-origin fish. Interbreeding that results in gene flow between hatchery-origin and natural-origin fish in nature can introduce hatchery-adapted traits into natural-origin populations, potentially affecting the genetic diversity and fitness of their progeny. Berejikian and Ford (2004) found that most studies of relative fitness involved steelhead, not salmon, and that most involved management scenarios where the hatchery-origin fish were non-local and had been subjected to considerable hatchery-influenced selection. Berejikian and Ford (2004) and the Recovery Implementation Science Team (2009), found few relative fitness studies involving species whose life histories involve minimal time in fresh water (e.g., chum salmon, pink salmon, and subyearling fall-run Chinook salmon).

Genetic information is not available for many salmon and steelhead populations, and even when it is, it is typically not possible to separately measure effects of the loss of within-population diversity, outbreeding, and hatchery-influenced selection. Surrogate metrics for inferring the magnitude of these risks are the proportion of natural spawners that consist of hatchery-origin fish (pHOS) which is often used as a surrogate measure of gene flow, and in the case of integrated[9] programs, the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportionate natural influence (PNI[10]). Appropriate cautions and qualifications need to be considered when using pHOS to analyze genetic risks from hatchery programs (e.g., environmental conditions and relative reproductive success). Guidelines for isolated programs are based on pHOS, but guidelines for integrated hatchery programs also consider PNI, which is a function of pHOS and pNOB. PNI is in theory a reflection of the relative strength of selection in the hatchery and natural environments: a PNI value greater than 0.5 indicates dominance of natural selective forces. Where PNI values exceed 0.5, it is hypothesized that the natural environment would drive adaptive change in the combined hatchery-origin and natural-origin population (HSRG 2004). Further, the premise is that traits in the combined population would remain similar to, or tend to change back toward characteristics that are more like a natural-origin population. Whether or not genetic characteristics would change back toward natural-origin populations and over what time frames, has not been tested empirically and is speculative.

NMFS considers available guidelines in analyzing genetic risks. For example, in 2004, the HSRG released recommendations for hatchery reform (HSRG 2005). The HSRG guidelines vary according to type of program and conservation importance of the population. In 2009, the HSRG recommended that primary populations (those of high conservation concern) affected by isolated hatchery programs have a pHOS of no more than 0.05, and no more than 0.10 for contributing[11] populations (HSRG 2009). The HSRG recommended that integrated hatchery programs have a PNI of at least 0.67 for primary populations and at least 0.5 for contributing populations, and a pHOS of less than 0.30 for either

[9] The intent of an integrated hatchery program is for the natural environment to drive the adaptation and fitness of a composite population of fish that spawns both in a hatchery and in the natural environment. Differences between hatchery-origin and natural-origin fish are minimized, and hatchery-origin fish are integrated with the local populations included in an ESU or DPS.

[10] PNI is a measure of hatchery influence on natural populations that is a function of both the proportion of hatchery-origin spawners spawning in the natural environment (pHOS) and the percent of natural-origin broodstock incorporated into a hatchery program (pNOB). PNI can also be thought of as a percentage of time all the genes of a population collectively have spent in the natural environment. PNI is computed as pNOB/(pNOB+pHOS).

[11] A population designation of “contributing” is similar to a Tier 2 population designation under NMFS’ PRA (NMFS 2010).

population category (HSRG 2009). The HSRG considered risks posed by highly diverged hatchery stocks and concluded that the risk from isolated hatchery programs increases dramatically as the level of divergence increases, especially if the hatchery-origin stock has been selected directly or indirectly (HSRG 2004). More recently, the HSRG suggested that perhaps pHOS levels should be lower than 0.05 for isolated programs and suggested that an effective pHOS level of 0.02 would be more appropriate for some programs based on modeling (HSRG 2014). The distinction between census pHOS (pHOS solely based on the numbers of fish on the spawning grounds) and effective pHOS is that effective pHOS is corrected for the lower reproductive success of hatchery-origin versus natural-origin fish, so is a more accurate measure of potential gene flow from hatchery programs. Ideally, effective pHOS equals gene flow. Higher levels of hatchery influence may be acceptable or even necessary when a population is at high risk or very high risk of extinction due to low abundance and a hatchery program is being used to conserve the population and reduce extinction risk in the short-term.

Genetic effects of hatchery programs are considered for the natural-origin fish of the same species as the hatchery-origin species resulting from hatchery programs operating in the Duwamish-Green River Basin. Interbreeding among different species of salmon and/or steelhead (either for hatchery-origin and natural-origin fish) rarely occurs and thus genetic effects are undetectable and are not analyzed in this EIS.

Chinook Salmon

There is one hatchery program producing fall-run Chinook salmon in the Duwamish-Green River Basin (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). The Soos Creek fall-run Chinook salmon program is an integrated harvest program that uses broodstock derived from the natural-origin Green River population. Available data suggest substantial genetic divergence has not occurred between hatchery-origin and natural-origin spawners, although both groups may be different to an unknown extent from the historical population because of hatchery-influenced selection that occurred during the 115 years the fish have been produced in hatcheries. Hatchery-origin Chinook salmon from other watersheds in southern Puget Sound have been recovered at the Soos Creek Hatchery rack, indicating that hatchery-origin strays could pose a genetic risk by spawning naturally in the Green River watershed (PS Hatcheries DEIS [NMFS 2014a]). However, based on a recent review of coded-wire tag recovery data, a very low percentage (less than 0.5 percent from 2009 to 2012) of the Chinook salmon returning to the Soos Creek Hatchery are from hatchery programs outside of the river basin (RMIS database query August 2016).

Over the long-term, hatchery-origin fish from the Soos Creek fall-run Chinook salmon program have likely experienced some extent of hatchery-influenced selection. There is overlap in hatchery-origin and natural-origin spawners in natural spawning areas, and the average percentage of hatchery-origin spawners in the Green River from 2009 to 2015 is about 66 percent of the total escapement of hatchery-origin and natural-origin fish (WDFW SCoRE database query). The percentage of natural-origin fish used as broodstock is about 12 percent (about 350 fish; 2008 to 2012 range of 7 percent to 20 percent) (WDFW 2013). From 2008 to 2012, the annual pNOB of 0.12 used in the Soos Creek hatchery program and pHOS of 0.54 result in a relatively low proportionate natural influence (PNI) of 0.19 (WDFW 2013).

For consultations and recovery planning purposes, the Duwamish-Green River Basin Chinook salmon is a Tier 2 population under NMFS' PRA (75 Fed. Reg. 82208, December 29, 2010; NMFS 2010; Subsection 1.7.12, Recovery Plans for Puget Sound Salmon and Steelhead). Tier 1 Chinook salmon populations are of primary importance for preservation, restoration, and ESU recovery and have to be viable for the ESU as a whole to meet viability criteria in Ruckelshaus et al. (2002). Tier 2 populations are less important than Tier 1 populations for recovery to a low extinction risk status. For integrated hatchery programs affecting contributing populations (similar to Tier 2 populations under the PRA), HSRG (2009) suggests PNI should be at least 0.5 (versus 0.67 for primary populations [similar to Tier 1 Chinook salmon populations under the PRA]). These conditions may affect the fitness and productivity of the natural-origin fall-run Chinook salmon population to some extent.

In summary, the integrated hatchery program overall has had a moderate negative genetic effect on the fall-run Chinook salmon population in the Duwamish-Green River Basin under existing conditions, primarily because although broodstock are of local origin, the pNOB is relatively low (12 percent), the PNI is relatively low (0.19), and the program size is relatively large (4,500,000 juveniles).

Steelhead

Adult returns of natural-origin steelhead are represented by two groups that return during different seasons of the year for spawning. Typically, adult natural-origin winter-run steelhead return to rivers and streams during the winter and spring, whereas summer-run steelhead return in the summer. Both groups spawn in the spring. Winter-run steelhead are native to the Duwamish-Green River Basin and natural-origin fish exist, but it is unclear if summer-run steelhead were native to the basin, and other than possible presence of some feral offspring from the summer-run steelhead hatchery program, natural-origin summer-run steelhead are not currently present (Myers et al. 2015).

As discussed in Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish Green River Basin, the timing of return and spawning by hatchery-origin steelhead is generally earlier than for their natural-origin counterparts. Hatchery-origin winter-run and summer-run steelhead from isolated hatchery programs tend to return earlier than historically because of intentional hatchery-influenced selection for earlier return timing (Myers et al. 2015; NMFS 2016c). Thus isolated hatchery-origin steelhead are generally referred to as "early" winter-run or summer-run steelhead.

As described above, there are two hatchery programs producing steelhead in the Duwamish-Green River Basin – the integrated Green River late winter-run steelhead program, and the Soos Creek isolated early summer-run steelhead (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). The integrated Green River late winter-run steelhead program is a small program (33,000 smolts annually) that uses locally returning natural-origin winter-run steelhead for at least 50 percent of its broodstock. These hatchery-origin fish represent the genetic diversity of the natural-origin steelhead population in the Duwamish-Green River Basin. However, the juvenile steelhead need to be reared in hatchery environments for 1 to 2 years to reach a size where the fish are ready to become smolts and migrate from fresh water to marine water, increasing the likelihood of hatchery-influenced selection (Araki et al. 2007). Collection of broodstock for the program may also inadvertently reduce the effective breeding size of the Green River natural-origin population, potentially reducing genetic diversity. This risk occurs if a substantial proportion of the total natural-origin Green River steelhead population is removed for use as broodstock. This risk is managed by limiting the proportion of natural-origin broodstock that could be removed annually to 20 percent or less of the natural-origin population (WDFW 2014c). Overall, these conditions help increase the potential for within-population genetic diversity to be maintained, decrease risks of outbreeding depression from hatchery-origin fish, and decrease the potential for hatchery-influenced selection.

The Soos Creek isolated early summer-run hatchery program produces 100,000 yearling smolts annually from fish returning to the Duwamish-Green River Basin that are based on fish of Skamania stock that originated in a tributary in the Lower Columbia River Steelhead DPS that were selectively bred for early return time and other characteristics and are considered to have been subjected to considerable hatchery-influenced selection. These hatchery-origin fish do not represent the genetic diversity of natural-origin steelhead population in the Duwamish-Green River Basin. Furthermore, Skamania summer-run steelhead are distinct from Puget Sound steelhead in that they possess 58 chromosomes, in contrast to the 60 chromosomes commonly found in Puget Sound fish (Hard et al.

2007). Natural-origin summer-run steelhead do not currently exist the Duwamish-Green River Basin, so the summer-run program poses no risk to natural-origin summer-run steelhead.

There can be some overlap in the time of spawn between the latest spawning hatchery-origin steelhead and the earliest spawning natural-origin steelhead (Figure 2). Spawner overlap creates the potential for interbreeding and outbreeding (gene flow) from early summer-run steelhead to natural-origin winter-run steelhead in the Duwamish-Green River Basin. The traits that are intentionally and inadvertently selected for in the hatchery environment (e.g., early spawn timing) make early summer-run steelhead ill-suited for survival and productivity in the natural environment. The effects on fitness of natural-origin winter-run steelhead from this gene flow is likely to be substantial, because the summer-run steelhead program was developed using broodstock originating in the Lower Columbia River Steelhead DPS (not from within the local Puget Sound Steelhead DPS), and gene flow between the DPSs would not be expected under natural conditions. Therefore, any successful reproduction of early summer-run steelhead on the spawning grounds in addition to early summer-run steelhead interbreeding with natural-origin winter-run steelhead, likely affects the genetic integrity and productivity of natural-origin winter-run steelhead in the Duwamish-Green River Basin.

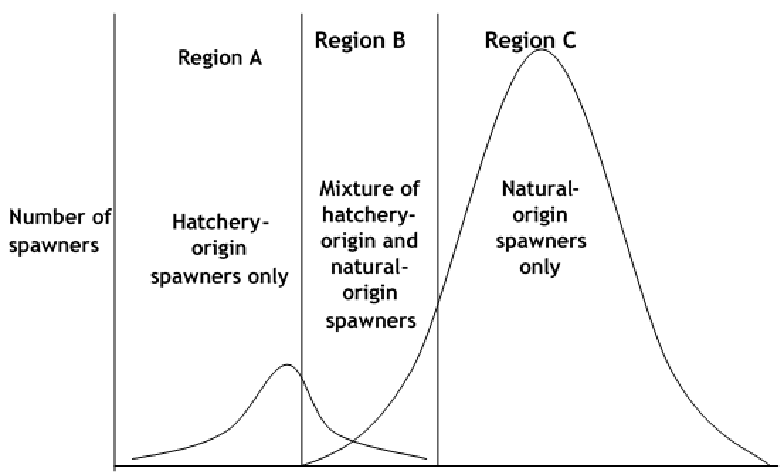

Figure 2. Conceptual diagram of temporal spawning overlap between isolated hatchery-origin steelhead and natural-origin steelhead. Shape, sizes and placement of curves is conceptual and is not meant to represent any specific situation (adapted from Scott and Gill 2008, Fig. 4-7).

Ultimately, gene flow is a concern because it can reduce the fitness of HxN progeny (where H indicates hatchery-origin fish and N indicates natural-origin fish) and the affected naturally spawning population generally. To address the relationship of gene flow to fitness, specifically for early winter steelhead programs, NMFS modeled the potential effect of gene flow on the fitness of natural-origin steelhead populations, as described in Appendix B, Genetic Effects Analysis of Early Winter Steelhead Hatchery Programs Proposed for the Nooksack, Stillaguamish, Dungeness, Skykomish, and Snoqualmie River Basins of Washington, in the EWS Hatcheries FEIS (NMFS 2016c). In that modeling exercise, NMFS concluded that early winter steelhead programs with a gene flow of less than 2 percent posed a low genetic risk to the fitness of natural-origin steelhead populations. Integrated programs for steelhead with a PNI of greater than 0.67 are also likely to pose a low genetic risk to natural-origin populations (HSRG 2009). WDFW's current statewide steelhead management plan is consistent with NMFS' findings for early summer-run and early winter steelhead isolated hatchery programs and states that isolated programs will result in average gene flow levels of less than 2 percent (WDFW 2008). The target gene flow level in WDFW's management plan was based on analysis of early winter steelhead programs that used the Ford (2002) model, the same model used to establish the HSRG guidelines.

Assessments of spawning by steelhead (and estimating pHOS) are difficult because high spring flows and associated turbidity hamper detection of spawners and redds (redds are the nests salmon and steelhead make in streambeds where eggs are deposited and fertilized). Available genetic information has documented introgression from hatchery-origin to natural-origin steelhead populations in Puget Sound in the past (e.g., Phelps et al. 1997; Winans et al. 2008; Pflug et al. 2013). However, based on genetic data (proportionate effective hatchery contribution [PEHC], Warheit Method) (EWS Hatcheries FEIS [NMFS 2016c]), average gene flow from early summer-run steelhead into the natural-origin Green River winter-run steelhead population from past practices is 1 percent (with a 90 percent confidence interval of 1 to 2 percent) (WDFW 2015), and 2 percent based on recent or projected practices EWS Hatcheries FEIS [NMFS 2016c]). Using another method (demographic gene flow [DGF], referred to as the Scott Gill Method in the EWS Hatcheries FEIS (NMFS 2016c), based on demographic information, NMFS estimated that gene flow from early summer-run steelhead into natural-origin Duwamish-Green River Basin winter-run steelhead from recent past practices is 2 percent and from more recent or projected practices is 2 percent, although estimates for projected practices range from 1.3 to 3.4 percent (WDFW 2015). Regardless of method, based on recent past practices (i.e., the last 5 to 10 years), and recent or projected practices, gene flow into natural-origin Duwamish-Green River Basin winter-run steelhead from the Soos Creek early summer-run steelhead hatchery program is 2 percent or less.

Additional information on genetic risks of hatchery programs to salmon and steelhead (e.g., considerations of residual hatchery-origin steelhead, which are juvenile steelhead that fail to out-migrate to the marine environment and can remain and spawn with adult steelhead) can be found in

Subsection 2.1.3, Genetics, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a). Information on spawner overlap and genetic risks to natural-origin winter-run steelhead from hatchery-origin summer-run steelhead (Skamania stock) can be found in Seamons et al. (2012), McMillan (2015a,b), and Appendix B, Genetic Effects Analysis of Early Winter Steelhead Programs, in the EWS Hatcheries FEIS (NMFS 2016c).

In summary, the two existing steelhead hatchery programs overall have had a high negative genetic effect on natural-origin winter-run steelhead in the Duwamish-Green River Basin under existing conditions, because of the genetic risks from the low level of outbreeding (gene flow) from the highly domesticated isolated Soos Creek early summer-run steelhead program, which is based on broodstock from outside of the Puget Sound Steelhead DPS.

Coho Salmon

Of the three coho salmon hatchery programs that exist in the Duwamish-Green River Basin, two (Soos Creek, with its associated cooperatives and release locations, and Keta Creek) are integrated harvest programs that use broodstock originating from the Green River and Soos Creek. As described in Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin, in past decades, other stocks were occasionally imported and used in the two integrated programs. However, the genetic impacts are not believed to have been significant, and the diversity represented by the current hatchery stock remains relatively uninfluenced by past stock transfers. This is supported by results of genetic analysis of a large sample of hatchery-origin Soos Creek coho salmon in the mid-1990s that indicated these fish remain significantly different from all other Washington coho salmon stocks (WDFW 2014a).

Broodstock for the third program (Marine Technology Center) are also derived from Soos Creek fish, but the program now uses adults returning to the Marine Technology Center facility. When there is a shortfall in eggs from returning adults, additional eggs are provided by the Soos Creek Hatchery. The Marine Technology Center program is small (10,000 yearlings) and is managed as an isolated program. Genetic effects from the program have been unlikely because there are no natural-origin coho salmon populations at or adjacent to the facility into which the relatively small number of returning adults could stray.

Over the long term, fish from the integrated coho salmon programs have likely undergone some extent of hatchery-influenced selection, and the programs may inadvertently have reduced the effective breeding size of the Green River natural-origin population, potentially reducing genetic diversity. In addition, as intended in integrated programs, there is overlap in hatchery-origin and natural-origin spawners in natural spawning areas. Natural-origin fish are included in hatchery broodstocks. For example, from 2009 to 2013, the annual pNOB of 0.33 used in the Soos Creek coho salmon program and pHOS of 0.16 result in a relatively high PNI of 0.68 (WDFW 2014a). Approximately 5 percent of the local broodstock used in the Keta Creek coho salmon program are from un-marked adults collected from the Green River at the TPU trap. Past levels of natural-origin fish used in this broodstock are unknown (Muckleshoot Indian Tribe and Suquamish Tribe 2017).

In summary, the three hatchery programs overall have had a low negative genetic effect on the coho salmon population in the Duwamish-Green River Basin under existing conditions, primarily because, although the genetic effect of hatchery-influenced selection has likely occurred and the size of the two integrated programs is relatively large (totaling 2,800,000 juveniles), broodstock used are of local origin, and the PNI for the Soos Creek coho salmon program is relatively high (WDFW 2014a; Muckleshoot Indian Tribe and Suquamish Tribe 2017).

Chum Salmon

There is one hatchery program that produces chum salmon in the Duwamish-Green River Basin that is operated as an integrated harvest program (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). This Keta Creek chum salmon program produces a considerable number of chum salmon juveniles (5,000,000 fry) using broodstock derived in part from the natural-origin Green River chum salmon population. In the early years of the program (1975 through 1995), broodstock were obtained from sources within Hood Canal and other areas in mid-Puget Sound (east Kitsap County). Since then, broodstock are obtained from returns to the Keta Creek Complex at Crisp Creek (Muckleshoot Indian Tribe 2014b).

Genetic effects on natural-origin chum salmon are primarily associated with potential reduction of genetic diversity by inadvertently reducing the effective breeding size of natural-origin spawners by use of considerable numbers of fish for broodstock (up to 5,000 adults), and hatchery-influenced selection.

There are few studies of genetic diversity of natural-origin or hatchery-origin chum salmon in the Duwamish-Green River Basin (e.g., Johnson et al. 1997). However, available studies of chum salmon genetic diversity (Small et al. 2009) and reproductive success (Berejikian et al. 2009) in other areas of Puget Sound have not found significant differences between natural-origin chum salmon and offspring of hatchery-origin chum salmon from hatchery programs using local broodstock. These findings are likely to be generally applicable to chum salmon in the Duwamish-Green River Basin because of similarities in the chum salmon hatchery practices used (e.g., short length of time spent in hatcheries). Although there are no comprehensive assessments of the extent of straying and spawning by hatchery-origin chum salmon in natural-origin chum salmon production areas in the analysis area, available studies of hatchery-origin chum salmon straying indicate that the fish have a high fidelity to their release sites (Fuss and Hopley 1991), and their tendency to stray is minimal.

In summary, the integrated Keta Creek chum salmon program has had a low negative genetic effect on the natural-origin chum salmon population in the Duwamish-Green River Basin under existing conditions, primarily because of potential reduced genetic diversity and hatchery-influenced selection associated with the substantial size of the program. These genetic risks are ameliorated by the use of local broodstock for hatchery production and the short time that the fish are reared in hatcheries.

3.2.3.2 Competition and Predation

Competition and predation between hatchery-origin fish and natural-origin fish may occur in both freshwater and marine areas, as well as between juveniles and adults and among different species of salmon and steelhead. Depending on the species and circumstances, competition and predation can lead to mortalities that affect the abundance and productivity of natural-origin fish. Information on competition risks from hatchery programs to natural-origin salmon and steelhead can be found in Subsection 3.2.3.1, Risks – Competition, in the PS Hatcheries DEIS (NMFS 2014a), and in Subsection 2.1.1, Competition, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a), and is summarized below. Information on predation risks from hatchery programs to natural-origin salmon and steelhead can be found in Subsection 3.2.3.2, Risks – Predation, in the PS Hatcheries DEIS (NMFS 2014a), and in Subsection 2.1.2, Predation, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a), and is summarized below.

Competition - Competition occurs when demand for limited resources (e.g., food and/or space) by two or more organisms exceeds available supply. Adverse impacts of competition on natural-origin fish from hatchery-origin fish may result from direct interactions (i.e., hatchery-origin fish interfere with access to limited resources by natural-origin fish) or indirect interactions (i.e., use of a limited resource by hatchery-origin fish reduces the amount of that resource available for natural-origin fish) (SIWG 1984). Hatchery-origin fish of different life stages may compete with natural-origin fish for food and spawning and rearing space. Juvenile, subadult, and adult hatchery-origin fish may compete with natural-origin salmon and steelhead for food resources and rearing space in freshwater, estuary, and marine habitats (Flagg et al. 2000; Naish et al. 2008). When adult hatchery-origin fish and natural-origin fish occur at the same time and place, hatchery-origin spawners may also compete with natural-origin spawners for mates and spawning habitat.

Competition risks between hatchery-origin and natural-origin salmon and steelhead may occur in both freshwater and marine areas, as well as between juveniles and adults. Juvenile hatchery-origin salmon and steelhead released into the natural environment primarily compete with natural-origin salmon and steelhead for resources when the hatchery-origin fish migrate downstream and may sometimes residualize (fail to emigrate to marine water). Species that rear in fresh water for 1 or more years make a physiological transition to become smolts and then typically out-migrate rapidly (e.g., steelhead, coho salmon, and spring-run Chinook salmon). Hatchery programs that pose the least competition risk are those that mimic the out-migration of natural-origin fish by producing rapidly migrating smolts that use rivers and streams as corridors to the ocean.

To help reduce risks to natural-origin fish, hatchery programs in Puget Sound are generally operated to release hatchery-origin juvenile fish as smolts after the peak of natural-origin salmon and steelhead out-migration periods. Hatchery-origin fish therefore out-migrate from high risk freshwater areas quickly and have a reduced opportunity to interact with the typically smaller natural-origin fish (Puget Sound Treaty Tribes and WDFW 2004). This strategy to release fish that rapidly migrate downstream to the estuary and marine environment reduces the risk of interaction and limits prospects for substantial competition with natural-origin fish reared in streams, rivers, and lakes (Flagg et al. 2000).

SIWG (1984) reviewed the freshwater resource competition risks posed by hatchery-origin fish to natural-origin salmon and steelhead. They categorized species combinations to determine if the risk (high, low, or unknown) of competition by hatchery-origin fish would have a negative impact on natural-origin salmon and steelhead in freshwater areas (Table 11). SIWG (1984) concluded that natural-origin Chinook salmon, coho salmon, and steelhead have a high risk of competition effects (both interspecific and intraspecific) from hatchery-origin fish of any of these three species.

Table 11. Risk of hatchery-origin salmon and steelhead competition on natural-origin salmon and steelhead in freshwater areas.

Hatchery-origin Species	Natural-origin Species					
	Steelhead	**Pink Salmon**	**Chum Salmon**	**Sockeye Salmon**	**Coho Salmon**	**Chinook Salmon**
Steelhead	H	L	L	L	H	H
Pink Salmon	L	L	L	L	L	L
Chum Salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	H	L	L	L	H	H
Chinook Salmon	H	L	L	L	H	H

Source: SIWG 1984
Note: H = High risk; L = Low risk; and U = Unknown risk of an impact occurring.

In particular, large releases of hatchery-origin fish could displace natural-origin fish from their preferred habitats within the vicinity of hatchery release locations (Steward and Bjornn 1990; Pearsons et al. 1994; Riley et al. 2004). Young natural-origin juveniles may be competitively displaced by hatchery-origin fish, especially when hatchery-origin fish are more numerous, are of equal or greater size, and (if hatchery-origin fish are released as pre-smolts) the hatchery-origin fish become residuals before natural-origin fry emerge from redds (Pearsons et al. 1994; Tatara and Berejikian 2012). Tatara and Berejikian (2012) also found that the density of natural-origin and hatchery-origin fish relative to habitat carrying capacity likely has a considerable influence on competitive interactions. However, Riley et al. (2004) found that small-scale releases of hatchery-origin Chinook salmon or coho salmon have few substantial ecological effects on natural-origin salmon fry in small coastal Washington streams, particularly when natural-origin fry occur at low densities.

Natural-origin salmon and steelhead spawners compete for habitat and mates (Naish et al. 2008). Salmon and steelhead females compete for spawning sites, whereas males compete to fertilize eggs. Hatchery-origin salmon and steelhead that spawn naturally in the analysis area may compete with their natural-origin counterparts for suitable spawning sites and mates (Flagg et al. 2000), and may spawn on gravels where natural-origin fish had spawned previously (called redd superimposition) thereby increasing competition risks to the natural-origin fish, particularly when suitable spawning habitat is limited. Adult competition risks are generally limited to interactions between hatchery-origin and natural-origin fish of the same species.

Estuarine and marine competition between hatchery-origin fish and natural-origin fish occurs when both types of fish occur in small estuaries where food supplies are limited. SIWG (1984) assessed potential intraspecific and interspecific risks to natural-origin salmon associated with hatchery-origin fish regarding resource competition in marine waters and determined most risks were unknown due to lack of data (Table 12). In the early marine life stage, when natural-origin fish enter marine waters and fish are concentrated in relatively small areas, food may be in short supply and competition is most likely to occur. This period is of especially high concern when hatchery-origin chum salmon and pink salmon compete with natural-origin chum salmon and pink salmon for food resources. There are no hatchery programs releasing pink salmon in the Duwamish-Green River Basin or in the central Puget Sound area.

Table 12. Risk of hatchery-origin salmon and steelhead competition on natural-origin salmon and steelhead in nearshore marine areas.

Hatchery-origin Species	Natural-origin Species					
	Steelhead	Pink Salmon	Chum Salmon	Sockeye Salmon	Coho Salmon	Chinook Salmon
Steelhead	H	U	U	L	U	U
Pink Salmon	U	H	H	U	U	U
Chum Salmon	U	H	H	U	U	U
Sockeye Salmon	L	U	U	H	U	U
Coho Salmon	U	U	U	U	H	U
Chinook Salmon	U	U	U	U	U	H

Source: SIWG 1984

Note: H = High risk; L = Low risk; and U = Unknown risk of an impact occurring.

Declines in average body size and weight-at-age of Pacific salmon observed during the 1980s and 1990s across the North Pacific Ocean were hypothesized to occur by Holt et al. (2008) because of the abundance of hatchery-origin fish that compete with natural-origin fish. However, research has not always concluded that competition by hatchery-origin fish exerts a density-dependent effect of reducing the growth and survival of natural-origin fish. McNeil (1991) found no clear density-dependent relationship between hatchery-origin and natural-origin fish that indicated competition was occurring in the marine environment.

An important consideration when evaluating competition in marine waters is that the actual number of juvenile hatchery-origin fish that reach Puget Sound marine waters is likely less than the total number released into fresh water from hatchery facilities. Mortality from piscivorous bird and fish predation, adverse flow conditions (floods, drought leading to stranding), and anthropogenic impacts (e.g., potential dewatering from dam operations, adverse water quality conditions from pollution, diversions into water bypass projects, and water intake screen entrainment) can substantially reduce post-release hatchery-origin fish survival to the estuary. Migration mortality increases with the distance hatchery-origin fish travel to reach an estuary. The proportion of the total estimated number of juvenile hatchery-origin salmon and steelhead reaching the Puget Sound estuary after release from hatchery facilities may range from nearly 100 percent for fish released directly into or very near the estuary to 50 percent or less for juvenile fish released in relatively low numbers and many river miles removed from marine waters (PS Hatcheries DEIS [NMFS 2014a]).

Overall, the risk of competition by hatchery-origin fish on natural-origin fish, and potential negative effects on mortality, abundance, and productivity, occurs in freshwater and marine areas when (1) hatchery-origin juvenile fish are of the same size as natural-origin fish and/or feed on similar prey, (2) hatchery-origin fish are present in large numbers compared to natural-origin fish, and (3) hatchery-origin fish occur in the same locations as natural-origin fish and for a longer time period (such as releases high in a watershed that result in a longer time for overlap between hatchery-origin and natural-origin fish).

Predation - Predation risks to natural-origin salmon and steelhead can result from hatchery-origin salmon and steelhead releases by direct predation (direct consumption) or indirect predation (increases in predation on natural-origin fish due to attraction of predators to releases of co-mingled hatchery-origin prey) (Roby et al. 2003). Predation risks in fresh water and marine waters generally occur when larger hatchery-origin salmon and steelhead species prey on smaller natural-origin salmon species.

Predation opportunities in fresh water are greatest when large numbers of hatchery-origin fish are released compared to natural-origin fish present in the release area, when older and larger juveniles (yearlings) are released, when hatchery-origin fish are released high in a watershed, and when salmon and steelhead residualize[12] in fresh water (residualism occurs when anadromous fish delay or fail to migrate from fresh water to the ocean). The latter two circumstances result in a longer period when

[12] Residualism pertains to hatchery-origin fish that out-migrate slowly, if at all, after they are released. Such fish are called residuals that residualize rather than out-migrate as most of their counterparts do.

natural-origin salmon and steelhead are exposed to hatchery-origin predators. Most studies of predation in fresh water suggest that hatchery-origin fish may prey on fish that are up to 50 percent of their length (Pearsons and Fritts 1999; HSRG 2004), whereas other studies suggest that hatchery-origin predators prefer smaller prey, generally up to 33 percent of their length (Horner 1978; Hillman and Mullan 1989; Columbia Basin Fish and Wildlife Authority 1996).

In fresh water, juvenile hatchery-origin steelhead have also been shown to prey on natural-origin Chinook salmon and sockeye salmon juveniles (Menchen 1981; Cannamela 1993; Sharpe et al. 2008). Sharpe et al. (2008) and Naman and Sharpe (2012) found that hatchery-origin steelhead prey on other salmonids to a very low extent during their migration seaward. Studies have documented predation by hatchery-origin coho salmon smolts on juvenile Chinook salmon, sockeye salmon, pink salmon, and chum salmon (Hargreaves and LeBrasseur 1986; Ruggerone and Rogers 1992; Hawkins and Tipping 1999).

SIWG (1984) categorized species combinations to determine if there is a high, low, or unknown risk of direct predation by hatchery-origin fish that would have a negative impact on natural-origin salmon and steelhead in fresh water. Predation risks in fresh water were found to be greatest to natural-origin pink salmon, chum salmon, and sockeye salmon from releases of larger sized hatchery-origin coho salmon, Chinook salmon, and steelhead (Table 13), because of the considerably smaller size of the prey species when they out-migrate from fresh water.

Table 13. Risk of hatchery-origin salmon and steelhead predation on natural-origin salmon and steelhead in freshwater areas.

Hatchery-origin Species	Natural-origin Species					
	Steelhead	**Pink Salmon**	**Chum Salmon**	**Sockeye Salmon**	**Coho Salmon**	**Chinook Salmon**
Steelhead	U	H	H	H	U	U
Pink Salmon	L	L	L	L	L	L
Chum Salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	U	H	H	H	U	U
Chinook Salmon	U	H	H	H	U	U

Source: SIWG 1984
Note: H = high risk, L = low risk, and U = unknown risk of an impact occurring.

SIWG (1984) also categorized the risk of direct predation by hatchery-origin fish on natural-origin salmon and steelhead in marine waters (Table 14). Predation risks in marine waters were found to be greatest to natural-origin pink salmon, chum salmon, and sockeye salmon from releases of yearling hatchery-origin coho salmon, Chinook salmon, and steelhead (Table 14). Duffy et al. (2005, 2010) found that juvenile Chinook salmon preyed on fish, consuming mostly sand lance and, in some instances, juvenile pink salmon. Yearling Chinook salmon were more reliant on fish prey, including pink salmon, chum salmon, and subyearling Chinook salmon. Juvenile pink salmon and chum salmon were the main prey of yearling coho salmon in north and south Puget Sound (Duffy 2009). The diets of hatchery-origin Chinook salmon and coho salmon in marine environments are generally similar to those of natural-origin fish. Similar to freshwater conditions, Chinook salmon and coho salmon may prey on fish up to 50 percent of their length in marine areas (Brodeur 1991).

Table 14. Risk of hatchery-origin salmon and steelhead predation on natural-origin salmon and steelhead in nearshore marine areas.

Hatchery-origin Species	Natural-origin Species					
	Steelhead	**Pink Salmon**	**Chum salmon**	**Sockeye Salmon**	**Coho Salmon**	**Chinook Salmon**
Steelhead	U	H	H	H	U	U
Pink Salmon	L	L	L	L	L	L
Chum Salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	U	H	H	H	U	U
Chinook Salmon	U	H	H	H	U	U

Source: SIWG 1984
Note: H = high risk, L = low risk, and U = unknown risk of an impact occurring.

Overall, as described in Subsection 2.1.2, Predation, in Appendix B, Hatchery Effects and Evaluation Methods for Fish, in the PS Hatcheries DEIS (NMFS 2014a), the risk of predation by hatchery-origin fish on natural-origin fish occurs in freshwater and marine waters when: (1) the hatchery-origin fish and their potential natural-origin prey overlap temporally; (2) the hatchery-origin fish and their potential natural-origin prey overlap spatially; and (3) the prey are less than about 50 percent of the length of the predatory fish. Chinook salmon, coho salmon, and steelhead that are released at the larger yearling life stage have the greatest potential to be predators, and smaller natural-origin pink salmon and chum salmon have the greatest potential to be prey.

Information on relative sizes and predominant freshwater occurrence and release timing for hatchery-origin and natural-origin salmon and steelhead juveniles is shown in Table 15.

Table 15. Relative size and predominant freshwater occurrence or release timing for natural-origin and hatchery-origin salmon and steelhead juveniles by life stage. Table adapted from the PS Hatcheries DEIS (NMFS 2014a).

Species/Origin	**Life Stage[1]**	**Size (Fork length in inches [mm])** Mean	Range	**Predominant Occurrence or Release Timing**
Chinook Salmon (natural-origin)	Fry	1.6 (40)	1.3-2.3 (34-59)	December-April
Chinook Salmon (natural-origin)	Parr	3.0 (75)	2.2-3.6 (57-92)	late May-July
Chinook Salmon (natural-origin)	Yearling	4.7 (120)	3.6-6.1 (92-154)	late March-May
Chinook Salmon (hatchery-origin)	Subyearling	3.1 (80)	2.2-3.4 (57-86)	May-June
Chinook Salmon (hatchery-origin)	Yearling	6.1 (155)	5.9-7.7 (150-196)	April
Steelhead (natural-origin)	Fry	2.4 (60)	0.9-3.9 (23-100)	June-October
Steelhead (natural-origin)	Parr	3.8 (96)	2.6-5.2 (65-131)	October-mid May
Steelhead (natural-origin)	Smolt	6.5 (165)	4.3-8.5 (109-215)	late April-June
Steelhead (isolated) (hatchery-origin)	Yearling	8.1 (206)	7.1-9.1 (180-230)	May
Steelhead (integrated) (hatchery-origin)[2]	Yearling+	7.4 (190)	7.0-8.3 (180-210)	May-June
Coho Salmon (natural-origin)	Fry	1.2 (30)	1.1-1.4 (29-36)	March
Coho Salmon (natural-origin)	Parr	2.1 (54)	1.5-2.9 (37-74)	April
Coho Salmon (natural-origin)	Yearling	4.2 (107)	2.9-7.5 (74-190)	late April-May
Coho Salmon (hatchery-origin)	Fry	1.7 (43)	1.5-2.5 (38-64)	March-April
Coho Salmon (hatchery-origin)	Subyearling	4.1 (104)	3.9-4.2 (99-107)	November
Coho Salmon (hatchery-origin)[3]	Yearling	5.5 (140)	5.2-6.1 (131-156)	April-June
Summer-run Chum Salmon (natural-origin)	Fry	1.5 (38)	1.3-2.0 (33-50)	March
Fall-run Chum Salmon (natural-origin)	Fry	1.5 (38)	1.3-2.0 (33-50)	April
Fall-run Chum Salmon (hatchery-origin)	Fry	2.0 (50)	1.7-2.0 (42-52)	May
Pink Salmon (natural-origin)	Fry	1.3 (34)	1.3-1.7 (32-43)	April-May

Table 15. Relative size and predominant freshwater occurrence or release timing for natural-origin and hatchery-origin salmon and steelhead juveniles by life stage. Table adapted from the PS Hatcheries DEIS (NMFS 2014a) (continued).

Species/Origin	**Life Stage**[1]	**Size (Fork length in inches [mm])**		**Predominant Occurrence or Release Timing**
		Mean	**Range**	
Pink Salmon (hatchery-origin)[4]	Fry	2.0 (50)	1.6-2.0 (40-52)	April
Sockeye Salmon (natural-origin)[5]	Fry	1.1 (28)	1.0-1.2 (25-31)	April-May
Sockeye Salmon (natural-origin)[5]	Lake phase fry[6]	2.0 (51)	1.3-4.7 (32-119)	June-March
Sockeye Salmon (natural-origin)[5]	Smolt	4.9 (125)	4.7-5.1 (120-129)	March-April
Sockeye Salmon (hatchery-origin)[5]	Fry	1.2 (30)	0.9-1.2 (24-30)	February-April

Notes and sources:

Natural-origin parr and yearling Chinook salmon data from Beamer et al. (2005) and WDFW juvenile out-migrant trapping reports (Seiler et al 2000, 2003, 2004; Volkhardt et al. 2006a, 2006b; Kinsel et al. 2007, 2008; Topping and Zimmerman 2011).

Natural-origin steelhead 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. 2007; Topping and Zimmerman 2011).

Natural-origin coho salmon data for Green River from Topping et al. (2008) (for smolts) and Beacham and Murray (1990) and Sandercock (1991) (for fry). Parr size range extrapolated from smolt and fry data considering year-round residence and Topping and Zimmerman (2011).

Natural-origin chum salmon data from Volkhardt et al. (2006a, 2006b) (Green River fall-run), and Tynan (1997) (summer-run).

Natural-origin pink salmon data from Topping et al. (2008) (Dungeness pink salmon) and Topping and Zimmerman (2011) (Green River pink salmon).

Natural-origin sockeye salmon data from Burgner (1991) for Lake Washington sockeye (predominantly 3-1 fish); parr size range extrapolated from smolt and fry data considering year-round residence.

Hatchery-origin fish release size and timing data are average individual fish size and standard release timing targets applied for hatchery salmon and steelhead production in Puget Sound (from WDFW salmon and steelhead HGMPs and WDFW and Point No Point Treaty Tribes [2000]).

[1] For this EIS, the key stages in the life histories of natural-origin and hatchery-origin juvenile salmon and steelhead are as follows: fry are very small, have absorbed their egg sac, are less than 1 year old (applies to hatchery-origin and natural-origin fish); subyearlings are small, less than 1 year old (typically applies to hatchery-origin releases); parr are juveniles from 1 to 3 years old depending on the species (typically refers to natural-origin fish); smolts are larger hatchery-origin and natural-origin juveniles that are undergoing their transformation from living in fresh water to living in the marine environment and are headed downstream to the ocean; yearlings are typically smolts that reared in the hatchery environment for a year prior to being released.

[2] Information is from the Green River late winter-run steelhead HGMP (WDFW 2014c).

[3] The vast majority of hatchery-origin coho salmon are released as yearlings.

[4] There are no hatchery programs that release pink salmon in south or central Puget Sound.

[5] The vast majority of hatchery-origin sockeye salmon are released as fry into Puget Sound lakes. No hatchery-origin sockeye salmon are released in the Duwamish-Green River Basin.

[6] Lake phase refers to juvenile fish rearing in a lake environment rather than a stream environment.

The following identifies the competition and predation risks in freshwater and marine areas posed by hatchery programs in the Duwamish-Green River Basin on natural-origin salmon and steelhead in the basin under existing conditions.

Chinook Salmon

Competition - Hatchery programs in the Duwamish-Green River Basin for fall-run Chinook salmon, steelhead, coho salmon, and chum salmon likely pose competition risks to natural-origin fall-run Chinook salmon under existing conditions. The Soos Creek fall-run Chinook salmon program annually produces up to 4,200,000 subyearlings and 300,000 yearlings (Table 3) that are released in the river at RM 34 or above, during the time natural-origin fall-run Chinook migrate seaward (Table 15). The program poses a competition risk to natural-origin fall-run Chinook salmon because of the relatively large number of subyearlings released and their similarity in size to natural-origin fall-run Chinook salmon out-migrating parr. In addition, these releases are made relatively high in the watershed. The average size of the hatchery-origin yearling fall-run Chinook salmon is larger than natural-origin fall-run Chinook salmon parr or yearlings, and these hatchery-origin fish are unlikely to compete with natural-origin fall-run Chinook salmon for food and space.

There are two hatchery programs (Soos Creek coho salmon and Keta Creek coho salmon) that release coho salmon in the Duwamish-Green River Basin annually, totaling up to 2,680,000 yearling hatchery-origin coho salmon (excluding releases of hatchery-origin coho salmon in marine areas) and two steelhead hatchery programs that release a total of up to 133,000 yearlings per year. The size of hatchery-origin coho salmon and steelhead yearlings, and hatchery-origin fall-run Chinook salmon yearlings, are larger than natural-origin fall-run Chinook salmon (Table 15), but these hatchery-origin fish present a competition risk because they are released at the same time and occupy the same freshwater areas during their outmigration as natural-origin fall-run Chinook salmon.

There is one hatchery program for chum salmon in the Duwamish-Green River Basin that releases up to 5,000,000 fry annually. Although the size of hatchery-origin chum salmon fry is smaller than the out-migrating natural-origin fall-run Chinook salmon (Table 15), chum salmon pose a competition risk because of the relatively large number of fish released, the release location that is relatively high in the basin (in lower Crisp Creek, entering the Green River near RM 40), and the overlap in timing of release and outmigration of natural-origin fall-run Chinook salmon (Table 15).

Hatchery-origin salmon and steelhead adults may compete with natural-origin fall-run Chinook salmon for spawning sites. However, adult competition risks are generally limited to interactions between hatchery-origin and natural-origin fish of the same species (Subsection 2.1.1.1.2, Adult Fish, in Appendix B, Hatchery Effects and Evaluation Methods for Fish, in the PS Hatcheries DEIS [NMFS 2014a]). Fish returning from the winter-run and summer-run steelhead programs (Table 16) spawn in the spring and Chinook salmon spawn in the fall months, so competition for spawning sites is unlikely.

Table 16. Timing of salmon and steelhead adult return and spawning in fresh water.

Species	Time of Return to Fresh Water	Spawn Timing
Fall-run Chinook Salmon	July to October	September through October
Steelhead (winter-run)	November to early June	Early March to mid-June
Steelhead (summer-run)	April through October	February through April
Coho Salmon	August to mid-November	Late October through mid-December
Chum Salmon	Early October to early January	Late November through December
Pink Salmon (odd-year)	Early August to October	September to October

Source: Washington Department of Fisheries et al. 1993

Competition effects on natural-origin fall-run Chinook salmon in estuarine and marine areas may also occur. However, SIWG (1984) concluded that risks of competition effects in marine waters were generally unknown because of lack of data. As described in Subsection 3.2.5.4.2, Risks – Competition – Marine, in the PS Hatcheries DEIS (NMFS 2014a), it is likely that effects primarily occur in estuarine areas adjacent to the river mouth where hatchery-origin fish may concentrate during their migration to marine waters.

In summary, hatchery programs in the Duwamish-Green River Basin overall have had a moderate negative competition effect on natural-origin fall-run Chinook salmon under existing conditions, primarily because of competition in fresh water associated with the large numbers of fish released (e.g., Chinook salmon subyearlings, coho salmon yearlings, and chum salmon fry) and their up-river locations of release.

Predation – As generally described in SIWG (1984), hatchery programs in the Duwamish-Green River Basin releasing yearling fall-run Chinook salmon, yearling steelhead, and yearling coho salmon pose predation risks to co-occurring natural-origin fall-run Chinook salmon. These hatchery programs release yearlings that are larger than the co-existing natural-origin fall-run Chinook salmon juveniles (Table 15), and releases occur relatively high in the watershed. Therefore the extent of overlap in time and space suggests these hatchery released fish may prey on natural-origin fall-run Chinook salmon. Although releases of yearling fall-run Chinook salmon and steelhead are relatively small (up to 300,000 and 133,000 yearlings, respectively), the total number of yearling coho salmon released into fresh water is relatively large (over 1 million fish). However, coho salmon out-migrants likely move out of the estuary and into the open ocean within 1 week. Similarly, hatchery-origin steelhead tend to move through and into marine areas in about 2 weeks (Simenstad et al. 1982; Moore et al. 2010, 2015).

To decrease the risks of competition and predation to natural-origin fall-run Chinook salmon, hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon, are released from late April to June (Table 15) when they are physiologically ready to enter marine water, and after the majority of natural-origin fall-run Chinook salmon have emigrated seaward. Predation by hatchery-origin fall-run Chinook salmon subyearlings on natural-origin fall-run Chinook salmon juveniles is unlikely because of their similarity in size. Since hatchery-origin chum salmon are released at a small size and migrate out of fresh water quickly (NMFS 2002), they are unlikely to pose a predation risk to natural-origin fall-run Chinook salmon.

Predation effects on natural-origin fall-run Chinook salmon in estuarine and marine areas may also occur. SIWG (1984) found relatively little data on predation in nearshore marine areas (Table 14), and concluded that predation risks to natural-origin fall-run Chinook salmon in nearshore marine areas are low from hatchery-origin chum salmon, and unknown for Chinook salmon, steelhead, and coho salmon. It is likely that predation from hatchery-origin fish on natural-origin fall-run Chinook salmon occurs in marine waters because of size differences and co-occurrence of these potential predators and prey (Appendix B, Hatchery Effects and Evaluation Methods for Fish, in PS Hatcheries DEIS [NMFS 2014a]). Although the extent of overlap in space and time is limited as the fish migrate through marine waters to the ocean, predation in marine areas is likely to be greatest between the larger hatchery-origin fall-run Chinook salmon yearlings and smaller natural-origin fall-run Chinook salmon subyearlings (with greatest overlap in areas adjacent to river mouths).

Beauchamp and Duffy (2011) estimated that several hundred thousand Chinook salmon from 1 to 3 years old reside in Puget Sound (these fish are sometimes locally referred to as blackmouth salmon[13])

[13] In contrast to releases at the subyearling stage, additional rearing of hatchery-origin fall-run Chinook salmon to the yearling stage fosters the tendency of the fish to remain in Puget Sound, where they can attain a large size (e.g., 22 inches) and are available for harvest. For more information on resident (blackmouth) Chinook salmon in Puget Sound, see Subsection 3.2.5.3, Description of Hatchery-origin Chinook Salmon, in the PS Hatcheries DEIS (NMFS 2014a).

for most or all seasons of the year and could consume 6 to 59 percent of the combined total of 15 to 18 million hatchery-origin and natural-origin juvenile Chinook salmon that the authors estimated would enter the marine waters of Puget Sound each year. Natural-origin fall-run Chinook salmon juveniles entering Puget Sound from the Duwamish-Green River Basin are vulnerable to predation from the resident Chinook salmon, some of which may originate from the Duwamish-Green River Basin.

In summary, hatchery programs in the Duwamish-Green River Basin overall have had a high negative predation risk, primarily because of the releases of hatchery-origin yearling fall-run Chinook salmon, yearling steelhead, and yearling coho salmon, whose sizes are large compared to smaller-sized natural-origin fall-run Chinook salmon, and due to spatial and temporal overlap during out-migration.

Steelhead

Competition - Hatchery programs in the Duwamish-Green River Basin that produce yearling fall-run Chinook salmon, steelhead, and coho salmon likely pose competition risks to natural-origin steelhead under existing conditions. The Soos Creek fall-run Chinook salmon program annually produces up to 300,000 yearlings that are released in the river at RM 34 or above during the time natural-origin steelhead smolts migrate seaward (Table 15). The Green River late winter-run steelhead program annually releases up to 33,000 smolts of 1 or more years of age, and the Soos Creek summer-run steelhead program annually releases up to 133,000 yearling smolts annually (Table 9). Releases from both steelhead programs are made in the upper river (RM 44 to 48), during the time that natural-origin steelhead smolts migrate seaward (Table 15).

The Soos Creek and Keta Creek coho salmon programs release a total of up to 2.68 million yearling hatchery-origin coho salmon per year into the basin. A small portion of the yearling coho salmon produced by the Soos Creek coho salmon program (30,000 yearlings), and almost half of the yearling coho salmon produced by the Keta Creek coho salmon program (1,000,000 yearlings) are transferred to the Elliott Bay net pens and are released into marine water. These two releases into marine water eliminate the risk of competition with natural-origin coho salmon in fresh water. Releases from the coho salmon programs in fresh water are made in the upper river (e.g., RM 34 and 40), during the time that natural-origin steelhead smolts migrate seaward (Table 15).

Hatchery releases of subyearling fall-run Chinook salmon, coho salmon fry, and chum salmon fry do not pose competition risks to natural-origin steelhead due to the small size of the fish released compared to the larger size of natural-origin steelhead out-migrants. However, programs producing yearling fall-run Chinook salmon, steelhead, and in particular coho salmon, pose competition risks to natural-origin steelhead, because the size of the yearlings released is similar to the size of the natural-origin steelhead smolts migrating seaward, and because the releases are made relatively high in the watershed, providing opportunities for competitive interactions as they out-migrate. However, the releases of hatchery-origin steelhead, fall-run Chinook salmon, and coho salmon as seawater-ready smolts that rapidly leave fresh water likely decreases the risk of competition between these hatchery-origin fish and natural-origin steelhead.

Hatchery-origin steelhead adults may compete with natural-origin steelhead for spawning sites. However, its effect is unknown, if it occurs. Competition between hatchery-origin salmon and natural-origin winter-run steelhead for spawning sites is unlikely because natural-origin steelhead return to fresh water and spawn in the spring, and salmon species spawn in the fall months, except for chum salmon (Table 16). Furthermore, adult competition risks are generally limited to interactions between hatchery-origin and natural-origin fish of the same species (Subsection 2.1.1.1.2, Adult Fish, in Appendix B, Hatchery Effects and Evaluation Methods for Fish, in the PS Hatcheries DEIS [NMFS 2014a]). The intent of the small late winter-run steelhead hatchery program (33,000 yearlings) is to conserve the natural-origin steelhead population by bolstering the population with hatchery-origin returns. Spawn timing differs between summer-run and winter-run steelhead (Scott and Gill 2008; NMFS 2016c); thus, competition effects on natural-origin winter-run steelhead from spawners returning from the Soos Creek summer-run steelhead program are unlikely.

Competition effects from hatchery programs in the Duwamish-Green River Basin on natural-origin steelhead in estuarine and marine areas may also occur. Although yearling hatchery-origin fall-run Chinook salmon that remain in Puget Sound after release pose a risk to larger steelhead smolts traveling through Puget Sound, the annual release of yearling fall-run Chinook salmon from the Soos Creek fall-run Chinook salmon hatchery program is relatively small (300,000 smolts) and is unlikely to pose a substantial risk. Competition effects are unlikely from hatchery-origin steelhead releases because once steelhead smolts enter the marine environment, the fish tend to move relatively promptly through Puget Sound marine areas (Moore et al. 2015) and beyond, where the hatchery-origin steelhead are dispersed and not present in numbers that would contribute to density-dependent effects (Hartt and Dell 1986; Light et al. 1989). Because hatchery-origin chum salmon are released at a small size and migrate out of fresh water quickly (NMFS 2002), they are unlikely to compete with natural-origin steelhead fry.

In summary, hatchery programs in the Duwamish-Green River Basin overall have had a moderate negative competition effect on natural-origin steelhead under existing conditions, primarily because of competition risks in fresh water from yearling fall-run Chinook salmon, steelhead, and coho salmon programs. The yearlings produced by these programs are similar in size to the natural-origin steelhead smolts migrating seaward, and the spatial and temporal overlap from releases that occur relatively high in the watershed provides opportunities for competitive interactions during outmigration. However, releases of yearling steelhead, fall-run Chinook salmon, and coho salmon as seawater-ready smolts that rapidly leave fresh water likely decrease the risk of competition between these hatchery-origin fish and natural-origin steelhead.

Predation – As generally described in SIWG (1984), releases from hatchery programs in the Duwamish-Green River Basin are unlikely to pose substantial predation risks to natural-origin steelhead in fresh water or (Table 13) or marine areas (Table 14). Natural-origin steelhead fry occur from June through October (Table 15), and no hatchery-origin yearlings are released during this period. Thus, there is no predation risk from hatchery-origin fish to natural-origin steelhead fry. Natural-origin steelhead parr occur from October through mid-May and are generally not susceptible to predation from hatchery-origin fish because they would be at a large size when hatchery-origin fish are released in the spring. However, hatchery-origin yearling steelhead release dates overlap part of the outmigration timing of natural-origin steelhead parr (May). Similarly, although the out-migration period for natural-origin steelhead yearlings may be at a time when other hatchery-origin fish are released, the large size of the steelhead yearlings (Table 15) would preclude other hatchery-origin fish from preying on natural-origin steelhead yearlings in freshwater and marine areas.

In summary, hatchery programs in the Duwamish-Green River Basin have had a negligible negative predation risk to natural-origin steelhead under existing conditions, because of fish size and outmigration timing differences between hatchery-origin releases and natural-origin steelhead in fresh water. There may be some predation from hatchery-origin steelhead yearlings whose release dates overlap the outmigration timing of natural-origin steelhead parr that are of a size to be vulnerable to predation by the larger yearlings.

Coho Salmon

Competition – Hatchery programs in the Duwamish-Green River Basin that produce yearling fall-run Chinook salmon, steelhead, and coho salmon likely pose competition risks to natural-origin coho salmon under existing conditions. The Soos Creek fall-run Chinook salmon program annually produces up to 300,000 yearlings that are released in the river at RM 34 or above, during the time natural-origin coho salmon smolts migrate seaward (April) (Table 15). The Green River late winter-run steelhead program annually releases up to 33,000 smolts of 1 or more years of age, and the Soos Creek summer-run steelhead program annually releases up to 100,000 yearling smolts annually (Table 9). Releases from both steelhead programs occur in the upper river (RM 44 to 48), during the time that natural-origin coho salmon smolts migrate seaward (Table 15).

The Soos Creek and Keta Creek coho salmon programs release a total of up to 2.68 million yearling hatchery-origin coho salmon per year into the basin. A small portion of the yearling coho salmon produced by the Soos Creek coho salmon program (30,000 yearlings), and almost half of the yearling coho salmon produced by the Keta Creek coho salmon program (1,000,000 yearlings) are transferred to the Elliott Bay net pens, and are released into marine water. In addition, the Marine Technology Center coho salmon program releases 10,000 yearling hatchery-origin coho salmon directly into marine areas. These three releases into marine water eliminate the risk of competition with natural-origin coho salmon in fresh water. About 96 percent of the hatchery-origin coho salmon are released as yearling smolts; 4 percent are released as fry. Releases into fresh water from these coho salmon programs occur in the upper river (e.g., RM 34 and 40), during the time that natural-origin coho salmon smolts migrate seaward (Table 15).

Hatchery releases of subyearling fall-run Chinook salmon and chum salmon fry do not pose competition risks to natural-origin coho salmon smolts due to the small size of the fall-run Chinook salmon subyearlings released (average 3.1 inches) (Table 15) compared to the larger size of natural-origin coho salmon smolts (yearling average of 4.2 inches) (Table 15). However, releases of hatchery-origin coho salmon fry may compete with natural-origin coho salmon where the two groups overlap in time and space and food is limited. Hatchery-origin fall-run Chinook salmon subyearlings and chum salmon fry are released in areas (MP 34 and MP 40 of Green River, respectively) that are downstream from locations of natural-origin coho salmon fry outmigration. The programs that produce and release yearling fall-run Chinook salmon, steelhead, and particularly coho salmon, in fresh water pose competition risks to natural-origin coho salmon, because the size of the yearlings released is similar to the size of the natural-origin coho salmon smolts migrating seaward and because the releases are made relatively high in the watershed, providing opportunities for competitive interactions as they out-migrate. However, the releases of hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon as seawater-ready smolts that rapidly leave fresh water likely decreases the risk of competition between these hatchery-origin fish and natural-origin coho salmon.

Competition with natural-origin coho salmon for spawning sites may occur from adult hatchery-origin coho salmon. In addition, although the time of chum salmon spawning is similar to coho salmon (Table 16), the two species spawn in different areas (chum salmon spawn in lower reaches, whereas coho salmon spawn in upper reaches and tributaries), thus reducing the risk of them competing for spawning sites (Subsection 2.1.1.1.2, Adult Fish, in Appendix B, Hatchery Effects and Evaluation Methods for Fish, in the PS Hatcheries DEIS [NMFS 2014a]).

In marine areas, the risks to natural-origin coho salmon from competition are greatest from hatchery-origin coho salmon yearlings (Table 14). Releases of hatchery-origin coho salmon yearlings into marine water include almost half of the coho salmon produced by the Keta Creek coho salmon program (1,000,000 yearlings) that are transferred to the Elliott Bay net pens for release, a small number produced by the Soos Creek coho salmon program (30,000 yearlings) that are transferred to the Elliott Bay net pens for release, and all of the fish produced by the small Marine Technology Center coho program (10,000 yearlings) that are released at Seahurst Park. Hatchery-origin steelhead yearling releases are unlikely to compete with natural-origin coho salmon in marine areas, because once the steelhead smolts enter the marine environment, the fish tend to move relatively promptly through Puget Sound marine areas (Moore et al. 2015) and beyond.

In summary, hatchery programs in the Duwamish-Green River Basin overall, have had a moderate negative competition effect on natural-origin coho salmon under existing conditions, primarily because of competition risks in fresh water from yearling fall-run Chinook salmon, steelhead, and coho salmon programs, and in marine areas from yearling fall-run Chinook salmon and coho salmon. The yearlings produced by these programs are similar in size to the natural-origin coho salmon smolts migrating seaward, and the spatial and temporal overlap from releases are made relatively high in the watershed provides opportunities for competitive interactions during outmigration. However, the releases of yearling steelhead, fall-run Chinook salmon, and coho salmon as seawater-ready smolts that rapidly leave fresh water likely decrease the risk of competition between these hatchery-origin fish and natural-origin coho salmon. In addition, there is some risk of competition effects on natural-origin coho salmon in marine areas from releases of yearling hatchery-origin coho salmon directly into salt water.

Predation – As generally described in SIWG (1984), releases from hatchery programs in the Duwamish-Green River Basin are unlikely to pose substantial predation risks to natural-origin coho salmon in freshwater (Table 13) or marine areas (Table 14). Natural-origin coho salmon fry occur in March (Table 15) and larger hatchery-origin yearlings are not released during this period. Thus, there is no predation risk from hatchery-origin yearlings to natural-origin coho salmon fry. Natural-origin coho salmon parr occur in April and are susceptible to predation from hatchery-origin coho salmon yearlings because of partial overlap of release dates between the hatchery-origin and natural-origin fish. Although the out-migration period for natural-origin coho salmon yearlings may be at a time when other hatchery-origin fish are released, the large size of the coho salmon yearlings (Table 15) would preclude other hatchery-origin fish from preying on natural-origin coho salmon yearlings in freshwater and marine areas.

Hatchery-origin fall-run Chinook salmon yearlings that reside in Puget Sound after release (blackmouth salmon) and hatchery-origin coho salmon that remain in Puget Sound (termed residents) may prey on natural-origin coho salmon during the first year of their marine rearing period if the natural-origin coho salmon outmigrants are of a small enough size to be vulnerable to predation (Buckley 1999). Hatchery-origin steelhead out-migrate in May and June after the out-migration of coho salmon fry and parr. Hatchery-origin chum salmon are released as fry, and their small size (Table 15) and non-piscivorous diet precludes them from being predators of natural-origin coho salmon.

In summary, hatchery programs in the Duwamish-Green River Basin have had a negligible negative predation risk to natural-origin coho salmon because of fish size and outmigration timing differences between most hatchery-origin releases and natural-origin coho salmon in fresh water. There is limited possibility of blackmouth salmon and resident hatchery-origin coho salmon feeding on coho salmon fry and parr, as well as limited predation by hatchery-origin coho salmon yearlings feeding on natural-origin coho salmon parr.

Chum Salmon

Competition – There is one hatchery program that produces chum salmon, the Keta Creek chum salmon program, which releases up to 5,000,000 fry annually. After the small natural-origin chum salmon fry hatch and emerge from stream gravels, they out-migrate promptly to marine waters. After their release from hatcheries, the potential for hatchery-origin chum salmon juveniles to compete for food and rearing space with natural-origin chum salmon juveniles in fresh water is minimal because interactions are of short duration and because releases of hatchery-origin chum salmon (May) occur after the peak out-migration period for natural-origin chum salmon (April) (Table 15). Thus, the chum salmon hatchery program in the Duwamish-Green River Basin is unlikely to pose a competition risk to natural-origin chum salmon in fresh water under existing conditions.

There are minimal risks of competition effects from hatchery-origin subyearling fall-run Chinook salmon to natural-origin chum salmon because subyearling fall-run Chinook salmon are released after the natural-origin chum salmon fry out-migration period (Table 15). In addition, hatchery-origin steelhead and coho salmon yearlings and fall-run Chinook salmon juveniles would not be expected to compete with natural-origin chum salmon for food and space because of the substantially larger size of these three species compared to natural-origin chum salmon fry (Table 15) and resulting preferences for different sizes of food items. Thus, hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon are not considered competitors with natural-origin chum salmon fry.

Competition with natural-origin chum salmon for spawning sites may occur from adult hatchery-origin chum salmon. However, this competition is unlikely since hatchery-origin chum salmon have high fidelity to areas of their release, resulting in limited straying potential. In addition, although the spawning time of hatchery-origin coho salmon is similar to natural-origin chum salmon (Table 16), the two species spawn in different areas (chum salmon spawn in lower reaches, whereas coho salmon spawn in upper reaches and tributaries), thus reducing the risk of the competition between the two species for spawning sites (Subsection 2.1.1.1.2, Adult Fish, in Appendix B, Hatchery Effects and Evaluation Methods for Fish, in the PS Hatcheries DEIS [NMFS 2014a]).

As described by SIWG (1984), the risk of competition effects from hatchery-origin chum salmon to natural-origin chum salmon is greatest in nearshore marine areas (Table 12). However, competition for food resources between hatchery-origin fall-run Chinook salmon and natural-origin chum salmon in Puget Sound marine areas is not likely a risk factor because of spatial and temporal differences in out-migration behaviors and residence time (SIWG 1984; Fresh 2006), as well as partitioning of available food resources among species (Duffy 2003; Brodeur et al. 2007).

In summary, hatchery programs in the Duwamish-Green River Basin overall have had a negligible negative competition effect on natural-origin chum salmon under existing conditions, primarily because of competition in nearshore marine areas associated with releases of hatchery-origin chum salmon fry, to the extent they overlap in time and space before they migrate to the ocean.

Predation – As generally described in SIWG (1984), hatchery programs in the Duwamish-Green River Basin releasing yearling fall-run Chinook salmon, yearling steelhead, and yearling coho salmon pose predation risks to co-occurring natural-origin chum salmon, due to their large size, compared to natural-origin chum salmon fry (Table 15). Predation may occur where and when piscivorous predators overlap in space and time with natural-origin fish of a size vulnerable to predation. Hatchery-origin juvenile salmon and steelhead can prey on smaller fish that are 40 to 50 percent of their body size. Predation from hatchery-origin chum salmon fry on natural-origin chum salmon fry does not occur because of similarities in fish size. (Table 15).

Releases of larger hatchery-origin fall-run Chinook salmon yearlings overlap the out-migration period for natural-origin chum salmon fry (Table 15). However, predation effects from the hatchery-origin fall-run Chinook salmon yearlings on natural-origin chum salmon are likely of limited duration because the hatchery-origin fall-run Chinook salmon would move away from river mouths and nearshore areas where natural-origin chum salmon fry initially concentrate a few weeks after their release (as reviewed for Chinook salmon and coho salmon in Appendix D, PCD RISK 1 Assessment, in the PS Hatcheries DEIS [NMFS 2014a]). Predation impacts from hatchery-origin fall-run Chinook salmon subyearlings are not expected because of the later release times for hatchery-origin fall-run Chinook salmon subyearlings that limits the potential for interaction with natural-origin chum salmon that are of a size vulnerable to predation (Table 15).

Hatchery-origin steelhead yearlings are released after the peak out-migration period for natural-origin chum salmon (Table 15) and pose a minimal predation risk. In contrast, hatchery-origin coho salmon yearlings are released during part of the peak out-migration of natural-origin chum salmon fry (Table 15), thus posing greater predation risk to natural-origin chum salmon.

In marine areas, predation effects from hatchery-origin fall-run Chinook salmon yearlings, steelhead yearlings, and coho salmon yearlings on natural-origin chum salmon are unlikely because, although the hatchery-origin fish are larger than natural-origin chum salmon, the hatchery-origin fish would be expected to emigrate rapidly toward the ocean.

In summary, hatchery programs in the Duwamish-Green River Basin overall, have had a low negative predation effect on natural-origin chum salmon under existing conditions, primarily from hatchery-origin fall-run Chinook salmon yearlings and hatchery-origin coho salmon yearlings in fresh water. The size of these hatchery-origin yearlings is large compared to the size of natural-origin chum salmon fry and the release timing of these hatchery-origin fish occurs during the peak out-migration period of natural-origin chum salmon fry, although the effect is decreased because chum salmon fry are expected to out-migrate rapidly from fresh water and because of foraging location differences among species.

Pink Salmon

Competition – There are no hatchery programs that release pink salmon in the Duwamish-Green River Basin, but natural-origin pink salmon occur in the river basin, and their abundance has increased in recent years (Topping and Zimmerman 2011). Natural-origin pink salmon, like natural-origin chum salmon and fall-run Chinook salmon, have life histories involving short freshwater residence periods. After emergence, the small natural-origin pink and chum salmon out-migrate promptly to marine waters as fry. Releases of hatchery-origin chum salmon fry within the Duwamish-Green River Basin pose limited competition risks to similar sized natural-origin pink salmon fry in freshwater, because the hatchery-origin chum salmon fry are released during part of the out-migration period for natural-origin pink salmon fry (Table 15), and spend only a limited amount of time in fresh water. After their release, the hatchery-origin chum salmon fry may compete with natural-origin pink salmon fry for food and rearing space to a greater extent in nearshore marine areas where the groups interact (SIWG 1984).

Hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon are not likely to pose substantial competition risks to natural-origin pink salmon in freshwater or marine waters because they are of a larger size and have different diet preferences from natural-origin pink salmon (Table 15).

In summary, hatchery programs in the Duwamish-Green River Basin overall, have had a negligible negative competition effect on natural-origin pink salmon under existing conditions, primarily because of competition in nearshore marine areas associated with releases of hatchery-origin chum salmon fry, to the extent they overlap in time and space before they migrate to the ocean.

Predation - As generally described in SIWG (1984), hatchery programs in the Duwamish-Green River Basin releasing fall-run Chinook salmon, steelhead, and coho salmon pose predation risks to co-occurring natural-origin pink salmon. Natural-origin pink salmon fry are smaller in size than yearling and subyearling fall-run Chinook salmon, yearling steelhead, and yearling coho salmon (Table 15). Predation may occur where and when piscivorous predators overlap in space and time with natural-origin fish of a size vulnerable to predation. Hatchery-origin juvenile salmon and steelhead can prey on smaller fish that are 40 to 50 percent of their body size. Releases of larger hatchery-origin fall-run Chinook salmon overlap the out-migration period for natural-origin pink salmon fry (Table 15). However, predation effects from the hatchery-origin fall-run Chinook salmon on natural-origin pink salmon are likely of limited duration because the hatchery-origin fall-run Chinook salmon move away from river mouths and nearshore areas where natural-origin pink salmon fry initially concentrate for a few weeks (as reviewed for Chinook salmon and coho salmon in Appendix D, PCD RISK 1 Assessment, in the PS Hatcheries DEIS [NMFS 2014a]).

Predation impacts from hatchery-origin fall-run Chinook salmon subyearlings in fresh water are limited because their release time partially overlaps the outmigration timing of natural-origin pink salmon fry that are of a size vulnerable to predation (Table 15). Similarly, hatchery-origin steelhead yearlings are also released during part of the out-migration period for natural-origin pink salmon fry (Table 15) and pose a limited predation risk. In contrast, hatchery-origin coho salmon yearlings are released about the same time as the peak out-migration of natural-origin pink salmon fry (Table 15), thus posing greater predation risk to natural-origin pink salmon fry.

In marine areas, predation effects on natural-origin pink salmon fry from the hatchery-origin fall-run Chinook salmon (yearlings and subyearlings), steelhead yearlings, and coho salmon yearlings occur when the fish congregate in estuary areas; however, the hatchery-origin fish would be expected to disperse rapidly toward the ocean.

In summary, hatchery programs in the Duwamish-Green River Basin overall have had a low negative predation effect on natural-origin pink salmon under existing conditions, primarily from hatchery-origin fall-run Chinook salmon (yearlings and subyearlings), steelhead yearlings, and coho salmon yearlings in fresh water and marine water. The size of these hatchery-origin yearlings is large compared to the size of natural-origin pink salmon fry and the release timing of these hatchery-origin fish at least partially occurs during times when natural-origin pink salmon fry out-migrate.

3.2.3.3 Facility Operations

Operating hatchery facilities can affect instream fish habitat in the following ways: (1) reduction in available fish habitat due to water withdrawals, (2) operation of instream structures (e.g., water intake structures, fish ladders, and weirs), or (3) maintenance of instream structures (e.g., protecting banks from erosion or clearing debris from water intake structures). More detailed information on the risks of salmon and steelhead hatchery facilities on natural-origin salmon and steelhead can be found in Subsection 2.1.4, Hatchery Facilities and Operations, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a).

Water withdrawals may affect instream fish habitat if they reduce the amount of water in a river between the hatchery's water intake and discharge structures. A full discussion of the effects of water withdrawal can be found in Subsection 3.1.1, Water Quantity, and is not discussed further in this subsection. In addition, hatchery effluents may affect the quality of waters downstream of hatchery facilities. A full discussion of the effects of the hatchery programs on water quality can be found in Subsection 3.1.2, Water Quality, and is not discussed further in this subsection.

The existing salmon and steelhead programs in the Duwamish-Green River Basin use hatchery facilities that have several instream structures such as water intakes, fish ladders, and weirs. Two programs (Soos Creek coho salmon and Keta Creek coho salmon) use net pens in marine water for fish rearing and release. Screening and passage associated with water intake structures and weirs are not applicable for those net pens. All hatchery intakes on salmon and steelhead streams are screened to prevent fish injury from impingement or permanent removal from streams. NMFS' screening criteria for water withdrawal devices set forth conservative standards that help minimize the biological risk of harming naturally produced salmonids and other aquatic fauna (NMFS 2011c). NMFS periodically updates its screening criteria based on best available science and technology. Consequently, some hatcheries have water intake screens that do not meet NMFS' most current screening criteria, although they meet the screening criteria that were in place when the water intake was installed. Hatchery facilities upgrade their water intake screens as funding becomes available.

Flaming Geyser Pond and Miller Creek Hatchery water intakes are screened consistent with NMFS' 2011 screening criteria, and the other facilities are screened consistent with older NMFS screening criteria (1995-1996) (Table 17). Water intake screens at the Soos Creek Hatchery and Keta Creek Complex do not meet current design criteria (NMFS 2011c) intended to minimize the risk of entrainment of juvenile natural-origin fish. In addition, the water intake structure at Soos Creek Hatchery is not compliant with current fish passage criteria. Due to steep stream gradient, no natural-origin salmon or steelhead rely on the Icy Creek watershed upstream of the Icy Creek Pond water intake. At Palmer Pond, no fish are present above the water intakes. Water intake screening structures are inspected several times per week to ensure they are operating correctly. Salmon and steelhead are not present upstream of the weir used at the Keta Creek Complex on Crisp Creek.

The existing salmon and steelhead hatchery programs in the Duwamish-Green River use several weirs to collect broodstock and/or manage adult returns. All applicable weirs are compliant with NMFS' current criteria for fish passage (Table 17). Unless fish passage is provided, weirs can be barriers to fish movement. The biological risks associated with weirs include the following:

- Isolation of formerly connected populations
- Limiting or slowing movement of non-target fish species
- Alteration of stream flow
- Alteration of streambed and riparian habitat
- Alteration of the distribution of spawning within a population
- Increased mortality or stress due to capture and handling
- Impingement of downstream migrating fish

- Forced downstream spawning by fish that do not pass through the weir
- Increased straying due to either trapping adults that were not intending to spawn above the weir or displacing adults into other tributaries

Table 17. Compliance of instream structures at hatchery facilities used for seven existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin with NMFS' screening and fish passage criteria.

	Criteria				
Facility	Do Water Intake Screens Meet NMFS' Current Screening Criteria? (NMFS 2011c)	Do Water Intake Screens Meet Older NMFS' Screening Criteria (NMFS 1995, 1996)?	Does the Hatchery Facility Operate Any Weirs?	Are Weirs Compliant with NMFS' Current Fish Passage Criteria? (NMFS 2011c)	Are All Water Intake Structures Compliant With NMFS' Fish Passage Criteria? (NMFS 2011c)
Soos Creek Hatchery	No	Yes	Yes	Yes	No
Icy Creek Pond[1]	NA	NA	No	NA	NA
Palmer Pond[2]	NA	NA	No	NA	NA
Flaming Geyser Pond	Yes	Yes	No	NA	Yes
Miller Creek Hatchery	Yes	Yes	No	NA	NA
Keta Creek Complex[3]	No	Yes	Yes	NA	NA

Sources: Muckleshoot Indian Tribe 2014b; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014b, 2014c, 2015

[1] Due to its extremely steep stream gradient, no natural-origin salmon or steelhead exist upstream of the Icy Creek pond water intake.

[2] No fish are present above the water intake.

[3] Salmon and steelhead are not present upstream of the Crisp Creek weir.

NA = not applicable.

By blocking migration and concentrating salmon and steelhead into a confined area, weirs may also increase the efficiency of mammalian predation on fish (RIST 2009). The following summarizes the use of weirs at existing hatchery facilities that rear salmon and steelhead in the Duwamish-Green River Basin.

Soos Creek Hatchery: The removable weir at the Soos Creek Hatchery is located on Soos Creek and operates from July through January of each year. Coho salmon (up to 3,000) and all natural-origin steelhead are allowed to pass upstream. From January to July, the weir is removed to continuously allow upstream passage of any coho salmon, chum salmon, and steelhead.

Icy Creek Pond: No weir operates at this facility.

Palmer Pond: No weir operates at this facility.

Flaming Geyser Pond: No weir operates at this facility.

Miller Creek Hatchery: No weir operates at this facility.

Keta Creek Complex: A weir operates at this facility in Crisp Creek, but there are no salmon and steelhead above the weir.

Instream maintenance may include clearing of debris and bedload from hatchery intake screens and fish ladders or protecting banks from erosion. Instream maintenance, such as clearing of debris and bedload from hatchery intake screens and fish ladders or protecting banks from erosion, may increase stream sedimentation. However, these maintenance activities are usually small in scale and duration and have beneficial restorative purposes that help return conditions to what they were when the structures were first constructed.

In summary, operation of hatchery programs in the Duwamish-Green River Basin overall, have had a low negative effect on natural-origin salmon and steelhead under existing conditions, primarily because not all of the facilities comply with current screening criteria or fish passage criteria, resulting in some potential for the abundance and distribution of fish to be negatively affected. However, effects on natural-origin salmon and steelhead migration from weir operations and instream maintenance activities are not substantial.

3.2.3.4 Masking

Masking occurs when unmarked hatchery-origin salmon and steelhead mix with and are included in population estimates of natural-origin fish, resulting in an overestimation of the abundance of natural-origin fish. Such masking hampers understanding of the composition of hatchery-origin and natural-origin fish in spawning areas, straying by hatchery-origin fish, performance of hatchery programs, and contributions of hatchery-origin and natural-origin fish to fisheries. Marking (e.g., adipose fin clip, coded-wire tag) allows hatchery-origin fish to be distinguished from natural-origin fish. Mass marking allows for monitoring of hatchery-origin fish straying into natural spawning areas, evaluations of performance of the hatchery programs in meeting juvenile to adult fish survival goals, fisheries directed specifically for hatchery-origin fish to conserve natural-origin populations, and, where applicable, contributions to natural spawning objectives.

Overlap between hatchery-origin and natural-origin fish in return timing and in spawn timing is an intended consequence of integrated hatchery programs, where the objective is to maintain similarity between the two groups (in contrast to isolated hatchery programs where the objective is to keep them separate). Of the seven existing hatchery programs in the Duwamish-Green River Basin, all but two programs (Soos Creek summer-run steelhead, and Marine Technology Center coho salmon) are integrated hatchery programs. There are no native summer-run steelhead in the Duwamish-Green River Basin, and return timing and spawn timing of summer-run adults differs from natural-origin winter-run steelhead (Scott and Gill 2008). Coho salmon releases from the Marine Technology Center program occur away from areas where natural-origin coho salmon occur. Thus, there are no masking effects on natural-origin fish from the isolated programs for Soos Creek summer-run steelhead or Marine Technology Center coho salmon.

For the five existing integrated hatchery programs, a total of 3,500,000 (78 percent) of the hatchery-origin fall-run Chinook salmon released into the Duwamish-Green River Basin from the existing Soos Creek hatchery program are mass-marked, so most of the hatchery-origin fish can be distinguished from natural-origin juveniles in fisheries and upon return as adults. All of the releases from the Soos Creek summer-run steelhead hatchery program are externally marked by removing their adipose fins, and all releases from the small Green River late winter-run steelhead program are internally marked by receiving blank wire tags. Nearly all of the coho salmon from the Soos Creek and Keta Creek coho salmon hatchery programs are marked by removal of their adipose fins. No chum salmon from the Keta Creek program are marked, and straying of these fish to natural spawning areas hampers evaluations of the status and spawner composition of natural-origin chum salmon. However, the hatchery operators are considering releasing fish with otolith[14] marks from these chum salmon programs to improve understanding of straying (Muckleshoot Indian Tribe 2014b). In total, with the exception of hatchery-origin chum salmon, about 84 percent of the hatchery-origin salmon and steelhead released into the river basin are mass-marked. There are no masking effects on natural-origin pink salmon because there are no hatchery programs for pink salmon in the project area.

[14] Otoliths (sometimes referred to as “ear bones”) are small structures in the heads of salmon and steelhead that can be thermally marked in hatchery conditions to produce a “barcode” (like growth rings on a tree). The otoliths can later be extracted from dead fish and examined in the laboratory to determine the code identifying where the fish originated.

In summary, masking effects associated with hatchery programs in the Duwamish-Green River Basin overall, have had a negligible negative effect on natural-origin salmon and steelhead under existing conditions, because (with the exception of chum salmon) a large percentage (84 percent) of the releases from the integrated hatchery programs are marked to allow hatchery-origin fish to be accounted for in abundance estimates of natural-origin fish.

3.2.3.5 Incidental Fishing

Fisheries (i.e., commercial, recreational, and tribal ceremonial and subsistence) targeting hatchery-origin fish may have incidental impacts on natural-origin fish. As described further below, this is because the fisheries targeting hatchery-origin salmon and steelhead occur when natural-origin salmon and steelhead may be present. General information on the risks to natural-origin fish from harvest can be found in Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish, and Subsection 2.1.5, Harvest Management, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a). Incidental fisheries impacts may occur in terminal areas (e.g., Duwamish-Green River Basin), in pre-terminal area mixed-stock marine fisheries (Puget Sound), and in United States and Canadian marine waters where mixed-stock fisheries target more abundant salmon stocks.

Within the Duwamish-Green River Basin and adjacent marine catch areas (e.g., Catch Areas 10 and 10A), commercial (tribal and non-tribal) and/or recreational fisheries exist for fall-run Chinook salmon, summer-run steelhead, coho salmon, and chum salmon that catch hatchery-origin fish produced by the programs operating in the basin. These fisheries may also result in incidental catches of natural-origin fish. The objectives for six of the seven existing hatchery programs in the Duwamish-Green River Basin (producing Chinook salmon, summer-run steelhead, coho salmon, and chum salmon) include harvest. The other hatchery program produces late winter-run steelhead whose primary objective is conservation, not harvest.

The harvest of fish in Puget Sound marine and freshwater areas is constrained so that it does not impede recovery of species listed under the ESA, which include Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, steelhead, southern green sturgeon, and Puget Sound/Georgia Basin rockfish. Fisheries that directly and incidentally harvest salmon and steelhead from the Duwamish-Green River Basin are summarized below.

Chinook Salmon: There are currently no fisheries (commercial, recreational, or tribal ceremonial and subsistence) that specifically target natural-origin fall-run Chinook salmon from the Duwamish-Green River Basin. However, although impacts are limited to certain times, gears, and areas, natural-origin fall-run Chinook salmon from the river basin are harvested incidentally in fisheries directed at hatchery-origin fall-run Chinook salmon, coho salmon, and chum salmon, and in small-scale tribal ceremonial and subsistence fisheries. Harvest of natural-origin and hatchery-origin fall-run Chinook salmon from the Duwamish-Green River Basin occurs in terminal areas (Elliott Bay [Catch Area 10A] and in the Green River) and in mixed stock fisheries in United States and Canadian marine waters.

Under the current harvest management plan (Puget Sound Indian Tribes and WDFW 2010), impacts on Green River Chinook salmon from fisheries in Washington outside the river basin are managed to not exceed a 15 percent southern United States exploitation rate, as estimated by the Fishery Regulation and Assessment Model (FRAM). When preseason harvest planning indicates that a low abundance threshold of 1,800 spawners will not be met, the impacts of Washington's pre-terminal fisheries on Green River Chinook salmon are managed to not exceed a 12 percent southern United States. exploitation rate, as estimated by FRAM. From 2005 through 2012, the total exploitation rate of Green River Chinook salmon averaged 50 percent (Puget Sound Indian Tribes and WDFW 2010; NMFS 2015).

Planned fisheries that affect listed Chinook salmon from the Duwamish-Green River Basin have been evaluated and conditionally approved annually by NMFS (e.g., NMFS 2011b). NMFS' most recent authorization for salmon fisheries, including those in the river basin (NMFS 2016d), addressed a 2016 Puget Sound harvest plan (Craig Bowhay, NWIFC, letter sent to Mike Grayum, Executive Director, NWIFC, April 22, 2016, regarding treaty salmon fisheries; Mike Grayum, NWIFC, letter to Bob Turner, Assistant Regional Administrator, NMFS, May 25, 2016, regarding harvest management objectives for Puget Sound Chinook salmon for the 2016-2017 season). The plan was found to be in compliance with the protective requirements of the ESA for listed salmon and steelhead. This most recent authorization of a harvest plan is relatively similar to those issued over the past several years, and future authorizations are expected.

Steelhead: There are no non-tribal commercial fisheries for steelhead in marine and freshwater areas, although there is some incidental harvest mortality from salmon fisheries. Tribal commercial and ceremonial and subsistence steelhead fisheries are conducted in Catch Area 10A, including the Green River.

Implementation of mark-selective rules for recreational fishing for steelhead began in Puget Sound in the 1990s. Under mark-selective fishing rules, recreational fishermen have only been able to retain steelhead with a clipped adipose fin. All hatchery-origin summer-run steelhead juveniles are mass-marked by having their adipose fins removed prior to their release. This allows for identification of the hatchery-origin fish during the fishery and prompt return of natural-origin fish to the water. Recreational fisheries for hatchery-origin early winter-run steelhead occurred in the past, but such fisheries no longer occur because there is no longer a hatchery program for early winter-run steelhead (EWS Hatcheries FEIS [NMFS 2016c]).

From 2000 to 2014, annual tribal and non-tribal harvests of listed winter-run steelhead in the river basin averaged 49 and 20 fish, respectively (WDFW steelhead database 2016). Following the listing of the Puget Sound Steelhead DPS in 2007, the 10-year average tribal harvest of natural-origin steelhead decreased from 115 to 5 fish. From the 2007-2008 through 2013-2014 return years, terminal harvest rates of natural-origin steelhead were low, averaging 1.6 percent (ranging from 0.3 to 3.5 percent) (NMFS 2015).

Planned fisheries that affect listed steelhead from the Duwamish-Green River Basin have been evaluated and conditionally approved annually by NMFS. NMFS' most recent authorization for salmon fisheries, including those in the action area (NMFS 2016d), analyzed a 2016 Puget Sound harvest plan assembled by the tribal co-managers (Craig Bowhay, NWIFC, letter sent to Mike Grayum, Executive Director, NWIFC, April 22, 2016, regarding treaty salmon fisheries; Mike Grayum, NWIFC, letter to Bob Turner, Assistant Regional Administrator, NMFS, May 25, 2016, regarding harvest management objectives for Puget Sound Chinook salmon for the 2016-2017 season). The plan was found to be in compliance with ESA protective requirements for listed salmon and steelhead. This most recent authorization of a co-manager harvest plan remained relatively similar to those issued over the past several years, and is expected to continue to do so.

Coho Salmon: Tribal commercial and ceremonial and subsistence fisheries, and non-tribal recreational fisheries target coho salmon (non-listed) returning to the Duwamish-Green River Basin. These fisheries harvest natural-origin Duwamish-Green River Basin coho salmon, and hatchery-origin coho salmon produced by tribal and state hatchery programs. Tribal commercial and ceremonial and subsistence fisheries for coho salmon occur in Elliott Bay (Catch Area 10A), and in the Green River, contingent on the availability of fish surplus to escapement needs. From 2006 to 2015, the tribal harvests of non-listed coho salmon in the net fishery in Catch Area 10A averaged 1,010 fish (ranging from 107 to 2,421 fish) (WDFW Run Reconstruction Spreadsheet 2016). Most harvest of coho salmon is of hatchery-origin fish. For example, from 2006 to 2015, tribal harvests in Catch Area 10A of coho salmon from hatchery programs in the Duwamish-Green River Basin averaged 882 fish (87 percent of the total coho salmon catch) (ranging from 87 fish [81 percent of the total] to 2,122 fish [88 percent of the total]). In addition, during the same time period, tribal net fishery harvests of hatchery-origin coho salmon in the Duwamish-Green River Basin averaged 31,772 fish (91 percent of the total coho salmon catch) (ranging from 12,237 fish [80 percent of the total] to 62,343 fish [95 percent of the total]).

Recreational fisheries targeting coho salmon occur in Catch Area 10 and in the Duwamish-Green River Basin, varying by time and area contingent on the availability of fish surplus to escapement needs. From 2006 to 2015, recreational harvests of coho salmon averaged 2,037 fish (ranging from 537 to 4,228 fish) (WDFW Run Reconstruction Spreadsheet 2016). During the same time period, recreational harvests of coho salmon in Catch Area 10 from hatchery programs in the Duwamish-Green River Basin averaged 2,076 fish (29 percent of the total coho salmon catch) (ranging from 356 fish [24 percent of the total] to 5,702 fish [32 percent of the total]). In addition, during the same time period, recreational harvests of hatchery-origin coho salmon in the Duwamish-Green River Basin averaged 1,863 fish (91 percent of the total coho salmon catch) (ranging from 514 fish [96 percent of the total] to 3,869 fish [92 percent of the total]).

Chum Salmon: Tribal and non-tribal commercial and non-tribal recreational fisheries target chum salmon (non-listed) returning to the Duwamish-Green River Basin. Tribal and non-tribal commercial fisheries for chum salmon occur in Catch Area 10, Elliott Bay (Catch Area 10A), and in the Green River, contingent on the availability of fish surplus to escapement needs. These fisheries harvest natural-origin Duwamish-Green River Basin chum salmon, and hatchery-origin chum salmon produced by the tribe's Keta Creek hatchery program.

From 2001 to 2015, the tribal and non-tribal harvests of hatchery-origin chum salmon in the net fishery in Catch Area 10 averaged 15,680 fish (ranging from 5,673 to 24,656 fish) (WDFW Run Reconstruction Spreadsheet 2015). During the same time period, tribal net harvests in Catch Area 10A of hatchery-origin chum salmon averaged 5,036 fish (ranging from 172 to 11,734 fish). In addition, during the same time period, tribal net fishery harvests of hatchery-origin chum salmon in the Duwamish-Green River Basin averaged 30,724 fish (ranging from 9,071 to 55,415 fish). Recreational fisheries target chum salmon in Catch Area 10 and in the Duwamish-Green River Basin. From 2000 to 2013, the recreational catch of chum salmon was 230 fish in Catch Area 10 and 524 fish in the Duwamish-Green River Basin.

Pink Salmon: Tribal and non-tribal commercial fisheries target odd-year pink salmon (non-listed) returning to the Duwamish-Green River Basin. These fisheries occur in Catch Area 10, Elliott Bay (Catch Area 10A), and in the Green River, contingent on the availability of fish surplus to escapement needs. From 2001 to 2013, tribal and non-tribal harvests of odd-year pink salmon in Catch Area 10 averaged 20,292 fish (ranging from 588 to 82,193 fish) (summary of WDFW Pink Salmon Run Reconstruction Workbooks 2001 through 2013). During the same time period, tribal harvests of odd-year pink salmon in Catch Area 10A averaged 1,313 fish (ranging from 0 to 7,488 fish), and tribal harvest of odd-year pink salmon in the Duwamish-Green River Basin averaged 25,209 fish (ranging from 43 to 68,266 fish).

Sockeye Salmon: There are no tribal or non-tribal fisheries that target the riverine sockeye salmon (non-listed) in the Duwamish-Green River Basin, and the abundance of these fish is unsubstantial. Therefore, as described in Subsection 3.2, Salmon and Steelhead (Introduction), sockeye salmon are not analyzed in Chapter 4, Environmental Consequences, in this EIS.

As described in the PS Hatcheries DEIS, Subsection 3.2.3, General Risks and Benefits of Hatchery Programs to Fish (NMFS 2014a), the effects of fisheries in Puget Sound and its tributaries on listed Chinook salmon, summer-run chum salmon, and steelhead, as well as other listed species are disclosed in the *Puget Sound Chinook Harvest Resource Management Plan Final Environmental Impact Statement* – herein referred to as the PS Harvest FEIS (NMFS 2004), which is a separate EIS analysis from the PS Hatcheries DEIS (NMFS 2014a). The PS Harvest FEIS (NMFS 2004) is herein incorporated by reference and its analysis and results are summarized in this EIS. Harvest impacts on listed species are also evaluated in ESA section 7 biological opinions and 4(d) Rule evaluations (e.g., NMFS 2015), specifically addressing the effects of the fisheries, as opposed to the hatchery programs. NMFS has determined that tribal (NMFS 2016d) and state harvest actions in Puget Sound would not jeopardize the Puget Sound Steelhead DPS (NMFS 2015). Based upon review of the alternatives and their environmental consequences described in the PS Harvest FEIS (NMFS 2004), and satisfaction of requirements under the ESA, NMFS approved conservation measures and harvest management objectives for Puget Sound Chinook salmon as defined in the Puget Sound Chinook Harvest RMP jointly developed by the Puget Sound treaty tribes and WDFW (NMFS 2005). The Chinook salmon harvest RMP approved by NMFS represents conservation measures and harvest management objectives for Puget Sound Chinook salmon that ensure productivity, abundance, and diversity of the populations comprising the Puget Sound Chinook Salmon ESU such that harvest does not appreciably reduce the likelihood of survival and recovery of the ESU. That RMP also provides for equitable sharing of harvest opportunity among tribes and treaty and non-treaty fishers, protects Indian treaty fishing rights, and meets Federal treaty trust responsibilities.

The benefits of harvest are described in this EIS in terms of socioeconomic effects and are reviewed in in Subsection 3.5, Socioeconomics, and evaluated by alternative in this EIS in Subsection 4.5, Socioeconomics.

In summary, considering all potential incidental fishing risks, the existing salmon and steelhead hatchery programs overall have had a negligible negative effect on the status of natural-origin salmon and steelhead in the Duwamish-Green River Basin, primarily because relatively few natural-origin fish are incidentally caught in fisheries, and NMFS determined that the impacts of harvest do not appreciably reduce the likelihood of survival and recovery of listed salmon and steelhead species in Puget Sound.

3.2.3.6 Disease

Bacterial, viral, fungal, and parasitic pathogens responsible for fish diseases (Table 18) can be present in both natural-origin and hatchery-origin salmon and steelhead (Hershberger et al. 2013). Interactions between hatchery-origin fish and natural-origin fish in the environment may result in the transfer of pathogens if either the hatchery-origin or the natural-origin fish are harboring fish disease. This impact may occur in tributary areas where hatchery-origin fish are released and throughout the migration corridor where hatchery-origin and natural-origin fish may interact. As the pathogens responsible for fish diseases are present in both hatchery-origin and natural-origin populations, there is some uncertainty associated with determining the source of the pathogens (Williams and Amend 1976; Hastein and Lindstad 1991). Hatchery-origin fish may have an increased risk of carrying fish disease pathogens because of relatively high rearing densities that increase stress and can lead to greater manifestation and spread of disease within the hatchery-origin population. Consequently, it is possible that the release of hatchery-origin salmon and steelhead may lead to an increase of disease in natural-origin salmon and steelhead.

Hatchery facilities within the Duwamish Green River Basin are operated in compliance with all applicable fish health guidelines (Integrated Hatchery Operations Team 1995; NWIFC and WDFW 2006 Pacific Northwest Fish Health Protection Committee 2007). These fish health guidelines ensure sanitation practices are applied, promote rearing and release of hatchery-origin fish in a healthy condition, and ensure that fish health is monitored. Pathologists from WDFW and the NWIFC monitor hatchery programs monthly (Muckleshoot Indian Tribe 2014b; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014b, 2014c, 2015). Exams performed at each life stage may include tests for viruses, bacteria, parasites, or pathological changes.

Table 18. Common fish pathogens found in hatchery facilities.

Pathogen	Disease	Species Affected
Renibacterium salmoninarum	Bacterial Kidney Disease	Chinook salmon, chum salmon, coho salmon, steelhead, and sockeye salmon
Ceratomyxa shasta	Ceratomyxosis	Chinook salmon, steelhead, coho salmon, and chum salmon
Flavobacterium psychrophilum	Coldwater Disease	Chinook salmon, chum salmon, coho salmon, steelhead, and sockeye salmon
Flavobacterium columnare	Columnaris	Chinook salmon, chum salmon, coho salmon, steelhead, and sockeye salmon
Yersinia ruckeri	Enteric Redmouth	Chinook salmon, chum salmon, steelhead, and sockeye salmon
Aermonas salmonicida	Furunculosis	Chinook salmon, chum salmon, coho salmon, steelhead, and sockeye salmon
Infectious hematopoetic necrosis	IHN	Chinook salmon, steelhead, chum salmon, and sockeye salmon
Nanophyetus salmincola	Nanophyetus	Chinook salmon, coho salmon, steelhead, and chum salmon
Saprolegnia parasitica	Saprolegniasis	Chinook salmon, coho salmon, steelhead, chum salmon, and sockeye salmon

Sources: IHN database http://gis.nacse.org/ihnv/; http://www.nwr.noaa.gov/Salmon-HarvestHatcheries/Hatcheries/Hatchery-Genetic-Mngmnt-Plans.cfm

Disease issues associated with hatchery programs using the Soos Creek Hatchery have occurred (WDFW 2015). The facility uses surfaces water (Subsection 3.1, Water Quantity) from an unscreened intake (Subsection 3.2.3.3, Facility Operation) in Big Soos Creek. Water withdrawn through the intake is untreated, and its use may have contributed to the incidence of disease (e.g., *Nanophyetes*) in hatchery-origin fall-run Chinook salmon, coho salmon, and steelhead. However, these disease risks at the Soos Creek Hatchery have been reduced by transferring fish for rearing from the hatchery to facilities that use springs or other water sources.

In summary, the hatchery programs in the Duwamish-Green River Basin overall have had a negligible negative effect on the transfer of diseases to natural-origin salmon and steelhead under existing conditions, primarily because the programs are operated in compliance with all fish health protection guidelines and monitoring.

3.2.3.7 Population Viability Benefits

Some salmon and steelhead hatchery programs can contribute to the viability of natural-origin populations and species. To assess the recovery status of listed species and their component populations, NMFS assesses four VSP parameters: abundance, diversity, spatial structure, and productivity (McElhany et al. 2000). Hatchery programs may also have negative effects on population viability via mechanisms discussed in Subsection 3.2, Salmon and Steelhead (especially Subsection 3.2.3.1, Genetics, and Subsection 3.2.3.2, Competition and Predation). As discussed in Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin, there are two types of hatchery programs (integrated and isolated).

Integrated hatchery programs (1) are reproductively connected (i.e., integrated) with a natural-origin population (if one still exists), (2) promote natural selection over hatchery selection, (3) contain genetic resources that represent the ecological and genetic diversity of a species, and (4) are included as part of an ESU or DPS. Only integrated hatchery programs may contribute to and benefit the viability of natural-origin populations; isolated programs provide no viability benefits. Detailed information on the population viability benefits of hatchery programs to natural-origin salmon and steelhead can be found in Subsection 2.2.2, Benefits – Viability, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a).

This subsection describes the benefits to natural-origin salmon and steelhead viability from the five integrated hatchery programs in the Duwamish-Green River Basin under existing conditions. Viability benefits are qualitatively assessed for the four VSP parameters for natural-origin salmon and steelhead. Useful information on listed Puget Sound Chinook salmon and steelhead is available from the most recent 5-year review of the status of listed salmon and steelhead (NWFSC 2015). Coho salmon and chum salmon are not listed in Puget Sound, thus information on those species is not included in NMFS status reviews every 5 years.

Chinook Salmon - NMFS listed fish from the Soos Creek fall-run Chinook salmon hatchery program in the Duwamish-Green River Basin under the ESA because the program exhibits a level of genetic divergence relative to the local natural population(s) that is not more than what occurs within the ESU (81 Fed. Reg. 72759, October 21, 2016). Listed Chinook salmon populations in the ESU are considered at high risk of extinction due to low abundance and productivity and declining trends in those parameters (NWFSC 2015). The natural productivity (returning adult offspring from natural spawners) of the Chinook salmon population in the Duwamish-Green River Basin has been below replacement (fewer than 1 adult offspring has returned from each parental spawner) since the mid-1980s (NWFSC 2015). NWFSC (2015) reported the 5-year geometric mean total spawner escapement for the Green River Chinook salmon population was 2,168 fish (from 2010 to 2014), a decline of 32 percent from the previous 5-year mean (3,187 fish). The estimated mean number of natural-origin spawners for this period was 897 fish.

The remaining fish spawning naturally (1,271 fish, or 58 percent of the mean spawning escapement) were hatchery-origin fall-run Chinook salmon (NWFSC 2015). These abundance levels are well below the minimum viable abundance target of 17,000 fish (Ford 2011). Due to the substantial size of the existing program (4,500,000 juveniles) and the low natural-origin abundance of fall-run Chinook salmon as described above, the program provides an important contribution to the abundance of fall-run Chinook salmon in the river basin. The hatchery program contributes substantially to the existing natural spawning population, uses natural-origin broodstock consistent with diversity present in the river basin, and thus bolsters use of available habitat by spawners in the river basin. Therefore, the hatchery program has the potential to provide abundance, diversity, and spatial structure benefits to the listed Green River Chinook salmon population. The contribution of the hatchery program to the productivity of the population is unknown.

In summary, the Soos Creek fall-run Chinook salmon hatchery program overall, has a moderate positive population viability benefit on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin under existing conditions, because fish from the program help to increase overall abundance, hatchery-origin fish have a similar level of genetic diversity as the natural-origin population, and the program provides hatchery-origin spawners that contribute to diversity and maybe productivity.

Steelhead – NMFS listed the fish from the Green River late winter-run steelhead program in the Duwamish-Green River Basin under the ESA because the program exhibits a level of genetic divergence relative to the local natural population(s) that is not more than what occurs within the DPS (81 Fed. Reg. 72759, October 21, 2016). Listed steelhead populations in the DPS (and especially in the central and south Puget Sound) are considered at high risk of extinction due largely to low abundance and productivity, and to a lesser extent to reduced diversity and spatial structure (NWFSC 2015). NWFSC (2015) reported the 5-year geometric mean spawner escapement for the Green River winter-run steelhead population was 552 fish (from 2010 to 2014), a decline of 23 percent from the previous 5-year mean (716), while also noting the early signs of an upward trend. These abundance levels are well below the minimum viable abundance target of 9,884 fish (Hard et al. 2015).

The Green River late winter-run steelhead hatchery program produces a relatively small number of fish (up to 33,000 yearlings). At this release level, if the smolt-to-adult survival rate ranged between 0.5 to 1 percent, returns would be from 115 to 330 adults. The percentage of fish from the program that spawn naturally is unknown (WDFW 2014c). However, abundance increased under a similar integrated winter-run steelhead program that is being evaluated in the Hamma Hamma River that enters Hood Canal (Berejikian et al. 2008). Thus, the Green River late winter-run steelhead program includes natural-origin broodstock that is consistent with diversity present in the river basin, and likely contributes to the existing natural spawning population to some extent and bolsters use of available habitat by steelhead spawners because hatchery-origin steelhead that are similar to the natural-origin fish also spawn naturally in the river basin.

In summary, the Green River late winter-run steelhead hatchery program in the Duwamish-Green River Basin overall has a negligible positive population viability benefit effect on the natural-origin winter-run steelhead population under existing conditions because the program has a similar level of genetic diversity as the natural-origin population, supports hatchery-origin spawning that contributes to diversity and productivity, and helps to increase overall abundance. Natural spawning by hatchery-origin steelhead may bolster use of available habitat, thereby contributing to spatial structure. However, the program's contribution is limited due to its small size (33,000 juveniles), and the extent of contribution of hatchery-origin steelhead to natural-origin spawning in the Duwamish-Green River Basin is unknown.

Coho Salmon – NMFS reviewed the status of coho salmon in Puget Sound (Weitkamp et al. 1995), identified ESUs, and determined that the status of the Puget Sound/Strait of Georgia Coho Salmon ESU did not warrant listing as threatened or endangered under the ESA. However, NMFS designated the Puget Sound/Strait of Georgia Coho Salmon ESU as a species of concern (sometimes called candidate species) due to declines in abundance and productivity, threats to genetic diversity, and reduced distribution (60 Fed. Reg. 38011, July 25, 1995; 75 Fed. Reg. 38776, July 6, 2010). For details on the Puget Sound/Strait of Georgia Coho Salmon ESU, see Subsection 3.2.9, Puget Sound/Strait of Georgia Coho Salmon ESU, in the PS Hatcheries DEIS (NMFS 2014a). Estimates of total coho salmon escapement to the Duwamish-Green River Basin are not available; however, the estimated average spawner escapement of coho salmon to Green River tributaries[15] was 2,918 fish from 2011 to 2015 (WDFW 2017).

[15] Estimates are based on indices from Hill, Newaukum, Spring, Cress, and North Fork Newaukum creeks.

There are two integrated hatchery programs for coho salmon in the Duwamish-Green River Basin. These programs (Soos Creek coho salmon, and Keta Creek coho salmon) produce a total of up to 2,800,000 juveniles annually (including 2,680,000 yearling smolts), and one small isolated (educational) program (Marine Technology Center coho salmon) releases 10,000 yearlings in an area removed from coho salmon natural production areas. Abundant returns of hatchery-origin coho salmon represent a substantial portion of the remaining genetic resources in the ESU (NMFS 2009). Viability benefits to natural-origin coho salmon likely occur from the two integrated coho salmon hatchery programs. Although the main objectives of these two hatchery programs are to provide harvest benefits, the programs likely contribute to the existing natural spawning population, include natural-origin broodstock consistent with the diversity present in the river basin, and may bolster use of available habitat by coho salmon spawners in the system. Therefore, the two integrated hatchery programs have the potential to provide abundance, diversity, and spatial structure benefits to the natural-origin coho salmon population. The contribution of the integrated hatchery program to the productivity of the population is unknown.

In summary, the two integrated coho salmon hatchery programs in the Duwamish-Green River Basin overall have had a moderate positive population viability benefit on the natural-origin coho salmon in the Duwamish-Green River Basin under existing conditions, primarily because the programs are of substantial size and include natural-origin broodstock consistent with the diversity present in the river basin, and help to increase total abundance of coho salmon. Natural spawning by hatchery-origin coho salmon may bolster use of available habitat, thereby contributing to spatial structure.

Chum Salmon – NMFS evaluated the status of the Puget Sound/Strait of Georgia Chum Salmon ESU in 1997 (Johnson et al. 1997), and found that the ESU is generally healthy, thereby determining that ESA listing was not warranted (63 Fed. Reg. 11773, March 10, 1998). For details on the Puget Sound/Strait of Georgia Chum Salmon ESU, see Subsection 3.2.10, Puget Sound/Strait of Georgia Chum Salmon ESU, in the PS Hatcheries DEIS (NMFS 2014a). Estimates of chum salmon spawning escapements in the Duwamish-Green River Basin are not available.

The Keta Creek integrated chum salmon hatchery program produces 5,000,000 chum salmon fry that are released in the Duwamish-Green River Basin. Viability benefits to natural-origin chum salmon would occur from the integrated chum salmon hatchery program. Although the main objectives of the program are to provide harvest benefits, and population data for chum salmon in the Duwamish-Green River Basin is limited, the program likely contributes to the existing natural spawning population, includes natural-origin broodstock consistent with the diversity present in the river basin, and may bolster use of available habitat by hatchery-origin chum salmon spawners in the river basin. Therefore, the hatchery program has the potential to provide abundance, diversity, and spatial structure benefits to the natural-origin chum salmon population. The extent of contribution of the integrated hatchery program to the productivity of the overall population is unknown.

In summary, the integrated chum salmon hatchery program in the Duwamish-Green River Basin overall has had a negligible positive population viability benefit on natural-origin chum salmon in the Duwamish-Green River Basin under existing conditions, because the program includes natural-origin broodstock consistent with the diversity present in the river basin, and helps to increase overall abundance. Natural spawning by hatchery-origin chum salmon may bolster use of available habitat, thereby contributing to spatial structure. Although the program releases a relatively large number of juveniles (5,000,000 fry), natural-origin chum salmon in the Duwamish-Green River Basin are generally healthy as indicated by their unlisted status.

3.2.3.8 Nutrient Cycling

During the time that salmon and steelhead live in marine environments, they consume food that contains nutrients found only in marine water (called marine-derived nutrients). After spawning and dying in freshwater spawning areas, salmon and steelhead (as well as carcasses resulting from hatchery operations that are manually placed in streams) decompose and release the marine-derived nutrients to the benefit of freshwater ecosystems (Cederholm et al. 2000). Salmon and steelhead carcasses and the nutrients they release provide direct and indirect food sources for juvenile salmon, steelhead, other fishes, aquatic invertebrates, and terrestrial animals. Although carcasses from all salmon and steelhead species may contribute marine-derived nutrients to some extent, the contributions of marine-derived nutrients from species that spawn relatively close to marine waters (i.e., chum salmon and pink salmon) are typically less than from species that spawn higher in watersheds (e.g., fall-Chinook salmon, coho salmon, steelhead). For a review of the contribution of marine-derived nutrients by salmon and steelhead in Puget Sound watersheds, see Subsection 3.2.3.7, Benefits – Marine-derived Nutrients, in the PS Hatcheries DEIS (NMFS 2014a), and Subsection 2.2.3, Benefits – Marine-derived Nutrients, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a).

From 2011 to 2015, for species for which estimates are available, an average of 4,670 salmon and steelhead spawned naturally (natural-origin and hatchery-origin fish combined[16]) in the Duwamish-Green River Basin (Table 19). Although escapements of chum salmon and pink salmon are not quantified, the numbers of spawners of these two species are considered to be substantial, especially in recent years for odd-year pink salmon (e.g., Topping et al. 2009; Topping and Zimmerman 2011). However, as mentioned above, chum salmon and pink salmon spawn in lower reaches of the river basin and thus their contribution to marine-derived nutrients into the ecosystem is less compared to species that spawn farther upstream, such as coho salmon, steelhead, and fall-run Chinook salmon.

After spawning, carcasses from hatchery broodstock are distributed by hatchery operators into the Duwamish-Green River Basin to contribute marine-derived nutrients. For example, from 2011 to 2015, an average of 1,821 hatchery-origin salmon and steelhead carcasses were distributed from WDFW hatchery facilities in the river basin (Soos Creek, Icy Creek, and Palmer hatchery facilities) (Table 19).

Table 19. Numbers of salmon and steelhead carcasses distributed from WDFW hatchery facilities, and average total spawning escapement in the Duwamish-Green River Basin from 2011 to 2015.

Species	Number of Carcasses Distributed						Average Escapement of Hatchery-origin and Natural-origin Spawners
	2011	2012	2013	2014	2015	Average	
Fall-run Chinook Salmon	313	206	71	11	957	311	848
Steelhead[1]	193	289	294	318	152	249	904
Coho Salmon	202	1,376	578	767	3,356	1,255	2,918
Chum Salmon	0	0	0	0	28	6	NA
Total	708	1,871	943	1,096	4,493	1,821	4,670

Sources: Catie Mains, WDFW, email sent to Christina Iverson, Fish Biologist, NMFS, November 9, 2016, regarding hatchery-origin carcasses (2012 to 2015); Catie Mains, WDFW, email sent to Steve Leider, Fish Biologist, NMFS, May 2, 2012, regarding hatchery-origin carcasses (2011); escapement data from WDFW SCoRE online database (accessed January 26, 2017).

[1] Includes a mix of carcasses from summer-run and winter-run broodstock.

Considering naturally spawning hatchery-origin fish plus the carcasses from hatchery broodstock distributed by hatchery operators, hatchery programs may contribute over 28 percent (1,821/6,491) of the carcasses and associated marine-derived nutrients to the basin each year under existing conditions.

[16] Comparable estimates of hatchery-origin and natural-origin spawner components are not available.

This percentage would likely differ if the estimates of hatchery-origin and natural-origin spawner escapements were distinguished, and if the contributions from escapements of natural-origin chum salmon and pink salmon were known, as well as the escapement of hatchery-origin chum salmon. Regardless, although they provide beneficial contributions of marine-derived nutrients, current contributions are well below the historical levels of marine-derived nutrients that were deposited into watersheds when returns of natural-origin salmon and steelhead to Puget Sound rivers were much larger (e.g., for historical and recent estimates of Puget Sound Chinook salmon escapement see Subsection 6.1, Historic and Current Naturally Spawning Adult Chinook Salmon Escapement, in Appendix C, Puget Sound Chinook Salmon Effects Analysis by Population, in the PS Hatcheries DEIS [NMFS 2014a]).

In summary, the salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall have had a low positive nutrient cycling effect in the Duwamish-Green River Basin under existing conditions, primarily because of the likely contributions from hatchery programs producing coho salmon, steelhead, and fall-run Chinook salmon that escape harvest and spawn naturally and from the carcasses distributed from hatchery operations.

3.3 Other Fish Species

This subsection describes existing conditions for fish species other than salmon and steelhead that may be affected by the alternatives, specifically, how changes in salmon and steelhead release numbers and hatchery program type may affect other fish species. The analysis focuses on natural-origin fish species that are self-sustaining in the natural environment and are dependent on aquatic habitat for migration, spawning, rearing, and food.

The analysis area for other fish species includes the geographic area where the Proposed Action would occur (Subsection 1.4, Project and Analysis Areas), and includes marine areas in Elliott Bay of Puget Sound (Subsection 1.4, Project and Analysis Areas), which is at the confluence of the Duwamish River with Puget Sound.

Additional information on other fish species in the analysis area and effects associated with Puget Sound salmon and steelhead hatchery programs can be found in Subsection 3.2, Fish, in the PS Hatcheries DEIS (NMFS 2014a). Many fish species in the Duwamish-Green River Basin, other than salmon and steelhead, have a relationship with salmon and steelhead as prey, predators, or competitors (Table 20).

The analysis area is not considered as one of the geographical areas occupied by the ESA-listed southern DPS of Pacific eulachon (76 Fed. Reg. 65324, October 20, 2011). Therefore, risks to this species is not considered further in this EIS.

Pacific lamprey and western brook lamprey are Federal "species of concern" and are Washington State "monitored species." In marine areas, several species of rockfish are listed as threatened under the ESA (Table 20). Pacific herring (a forage fish for salmon and steelhead) is a Federal species of concern and a state candidate species. All of these species, and other fish species that have relationships with salmon and steelhead, have ranges that include the analysis area. However, none of these species is located exclusively in the analysis area, and the area is generally a very small part of their total range (e.g., Subsection 3.2, Fish, in the PS Hatcheries DEIS [NMFS 2014a]). Therefore, risks to these species from salmon and steelhead hatchery programs in the Duwamish-Green River Basin are not considered further in this EIS.

Table 20. Range and status of other fish species in Puget Sound that may be affected by salmon and steelhead hatchery programs in the Duwamish-Green River Basin.

Species	Federal/State Listing Status	Type of Interaction with Salmon and Steelhead[1]
Bull trout	Federally listed as threatened	• Predator on salmon and steelhead eggs and juveniles • May compete with salmon and steelhead for food • May benefit from additional marine-derived nutrients provided by hatchery-origin fish
Rainbow trout	Not listed	• Predator of salmon and steelhead eggs and fry • Potential prey item for adult salmon and steelhead • May compete with salmon and steelhead for food and space • May interbreed with steelhead • May benefit from additional marine-derived nutrients provided by hatchery-origin fish

Table 20. Range and status of other fish species in Puget Sound that may be affected by salmon and steelhead hatchery programs in the Duwamish-Green River Basin (continued).

Species	Federal/State Listing Status	Type of Interaction with Salmon and Steelhead[1]
Coastal cutthroat trout	Not listed	• Predator of salmon and steelhead eggs and fry • Potential prey item for adult salmon and steelhead • May compete with salmon and steelhead for food and space • May interbreed with steelhead • May benefit from additional marine-derived nutrients provided by hatchery-origin fish
Pacific, river, and western brook lamprey	Not listed. Pacific lamprey, western brook lamprey, and river lamprey are federal species of concern, river lamprey is a Washington State candidate species.	• Potential prey item for adult salmon and steelhead • May compete with salmon and steelhead for food and space • May be a parasite on salmon and steelhead while in marine waters • May benefit from additional marine-derived nutrients provided by hatchery-origin fish
White sturgeon	Not federally listed	• May compete with salmon and steelhead for food • May benefit from additional marine-derived nutrients provided by hatchery-origin fish
Margined sculpin	Washington State sensitive species	• Predator on salmon and steelhead eggs and fry • Potential prey item for adult salmon and steelhead • May compete with salmon and steelhead for food and space • May benefit from additional marine-derived nutrients provided by hatchery-origin fish
Umatilla and leopard dace	Not federally listed, Washington State candidate species	• May compete with salmon and steelhead for food • May benefit from additional marine-derived nutrients provided by hatchery-origin fish

Table 20. Range and status of other fish species in Puget Sound that may be affected by salmon and steelhead hatchery programs in the Duwamish-Green River Basin (continued).

Species	Federal/State Listing Status	Type of Interaction with Salmon and Steelhead[1]
Mountain sucker	Not federally listed, Washington State candidate species	• Occurs in similar freshwater habitats, but is a bottom feeder and has a different ecological niche • May benefit from additional marine-derived nutrients provided by hatchery-origin fish
Northern pikeminnow	Not listed	• Freshwater predator on salmon and steelhead eggs and juveniles • May compete with salmon and steelhead for food • May benefit from additional marine-derived nutrients provided by hatchery-origin fish
Rockfish	One species is federally listed as endangered, two species are federally listed as threatened, and 13 species are Washington State candidate species[2]	• Predators of juvenile salmon and steelhead • Juveniles are prey for juvenile and adult salmon • May compete with salmon and steelhead for food
Forage fish	Pacific herring is a Washington State candidate species	• Prey for juvenile and adult salmon and steelhead • May compete with salmon and steelhead for food

Sources: Krohn 1968; Horner 1978; Beamish 1980; Finger 1982; Maret et al. 1997; WDFW 2016; USFWS 2016

[1] Data on interactions specifically between other fish species and hatchery-origin salmon and steelhead is limited. Therefore, this table identifies interactions between other fish species and salmon and steelhead in general. In addition, for the purposes of this EIS, the interactions of other fish species with hatchery-origin salmon and steelhead are assumed to be similar to interactions between other fish species and natural-origin salmon and steelhead.

[2] Georgia Basin bocaccio DPS (*Sebastes paucispinis*) - Federally listed as endangered and Washington State candidate species; Georgia Basin yelloweye rockfish DPS (*S. ruberrimus*) - Federally listed as threatened and Washington State candidate species; Georgia Basin canary rockfish DPS (*S. pinniger*) - Federally listed as threatened and Washington State candidate species; Black, brown, China, copper, green-striped, quillback, red-stripe, tiger, widow and yellowtail rockfish are Washington State candidate species.

In addition to Chinook salmon and steelhead, bull trout in the analysis area are also listed as a threatened fish species under the ESA. In the final recovery plan (USFWS 2015a), bull trout in the Duwamish-Green River Basin are part of the Coastal Recovery Unit located in western Washington and Oregon, but are not a current or historic core area. However, the lower Green River and Duwamish River areas in the Duwamish-Green River Basin, are considered Critical Habitat for bull trout (75 Fed. Reg. 63898, October 18, 2010) The lower Green and Duwamish Rivers are also considered bull trout foraging, migration, and overwintering habitat (USFWS 2015b). As summarized in the PS Hatcheries DEIS (NMFS 2014a), bull trout prey on a variety of terrestrial and aquatic insects, zooplankton, and small fish, including salmon and steelhead eggs and juveniles. Historically, bull trout may have occurred in the Green River upstream of Howard Hanson Dam (summary review in Tacoma Water 2001) but are not currently known to occur above the dam, which does not provide fish passage.

Under existing conditions, bull trout may be affected by salmon and steelhead hatchery programs in the Duwamish-Green River Basin primarily through predation (bull trout feed on salmon and steelhead) and facility operations (water intakes and weir use [Subsection 3.2.8, Washington Coastal-Puget Sound Bull Trout DPS in the PS Hatcheries DEIS (NMFS 2014a), and Subsection 3.4, Washington Coastal-Puget Sound Bull Trout in Appendix B of the PS Hatcheries DEIS (NMFS 2014a)]). The existing hatchery programs in the Duwamish-Green River Basin have a negligible positive effect on the bull trout Coastal Recovery Unit in the analysis area because: (1) there is a low presence of bull trout in the Duwamish-Green River Basin, (2) few bull trout are intercepted at hatchery weirs and during in-river broodstock collection activities because primary spawning and rearing habitat for bull trout is not known to occur in areas where water intake and weirs are located, and (3) bull trout would benefit from hatchery-origin salmon and steelhead releases because they may eat juvenile salmon and steelhead.

In summary, as shown in Table 20, existing hatchery programs in the Duwamish-Green River Basin have had negative and positive effects on other fish species. Because these hatchery programs are specific to the Duwamish-Green River Basin and the other fish species shown in Table 20 range throughout the Puget Sound, the overall effect of the existing hatchery programs on other fish species has been negligible, and positive (for other fish species that prey on hatchery-origin fish) or negative (for other fish species that are prey for or compete with hatchery-origin fish) (Subsection 3.2, Fish, in the PS Hatcheries DEIS [NMFS 2014a]).

3.4 Wildlife – Southern Resident Killer Whale

This subsection describes existing conditions for wildlife. It is narrowed to a discussion of Southern Resident killer whales, which may be affected by the alternatives (Subsection 3, Affected Environment [introduction]), specifically, how changes in salmon and steelhead release numbers and hatchery program type may affect this species. The information on other wildlife species in the analysis area and effects associated with Puget Sound hatchery programs is found in Subsection 3.5, Wildlife, in the PS Hatcheries DEIS (NMFS 2014a), which is incorporated by reference to this EIS. In that analysis, extensive information on other wildlife species in the analysis area was reviewed, and effects associated with Puget Sound hatchery programs on most wildlife species were not substantial.

As described in the PS Hatcheries DEIS (NMFS 2014a), hatchery operations have the potential to affect wildlife by changing the total abundance of salmon and steelhead prey or predators in aquatic and marine environments. Many wildlife species consume salmon and steelhead, which may benefit their survival and productivity through the nourishment provided. Increases or decreases in the abundance of juvenile and adult salmon and steelhead associated with the salmon and steelhead hatchery operations in the Duwamish-Green River Basin may, therefore, affect the viability of wildlife species that prey on these salmon and steelhead. In general, hatcheries could affect wildlife through transfer of toxic contaminants from hatchery-origin fish to wildlife, the operation of weirs (which could block or entrap wildlife, or conversely, make salmon and steelhead easier to catch through their corralling effect), or predator control programs (which may harass or kill wildlife preying on juvenile salmon and steelhead at hatchery facilities). As described in PS Hatcheries DEIS (NMFS 2014a), the effects of salmon and steelhead hatchery programs on wildlife species are generally negligible, and wildlife species in the analysis area would continue to occupy their existing habitats in similar abundances and feed on a variety of prey, including salmon and steelhead.

The analysis area for wildlife resources includes the geographic area where the Proposed Action would occur (Subsection 1.4, Project and Analysis Areas), including marine areas in Puget Sound (Subsection 1.4, Project and Analysis Areas). The analysis area supports a variety of birds, large and small mammals, amphibians, marine mammals, and freshwater and marine invertebrates that may eat or be eaten by salmon and steelhead as described in Subsection 3.5, Wildlife, in the PS Hatcheries DEIS (NMFS 2014a).

From a recent review of listed wildlife likely to occur in the project area, there are seven wildlife species that are federally listed as endangered or threatened under the ESA (USFWS 2016) and six wildlife species listed as Washington State endangered or threatened (WDFW 2016) (Table 21). Four of the species (spotted owl, streaked horned lark, yellow-billed cuckoo, and gray wolf) have little to no relationship with salmon and steelhead in the wildlife analysis area, or with salmon and steelhead hatcheries, and impacts on these species associated with the alternatives would be negligible (Cederholm et al. [2000] and Subsection 3.5.3.1, ESA-listed Species, in the PS Hatcheries DEIS [NMFS 2014a]).

One species (Oregon spotted frog) is a water-dependent aquatic native frog that occurs in the Pacific Northwest, and is almost always found in or near a perennial body of water that includes zones of shallow water and abundant emergent or floating aquatic plants. Oregon spotted frogs prey on insects, and can be consumed by fish species, particularly bull trout (79 Fed. Reg. 51658, August 29, 2014). However, the species does not have a relationship with salmon and steelhead, and the Duwamish-Green

River Basin is outside of its critical habitat (81 Fed. Reg. 29336, May 11, 2016). Consequently, existing hatchery programs would not affect its current habitat use and distribution.

Table 21. Federal and Washington State threatened and endangered species in the Puget Sound that may be affected by salmon hatchery programs in the Duwamish-Green River Basin.

Species	Current Federal Endangered Species Act Listing Status	Washington State Listing	Relationship with Salmon and Steelhead
Oregon spotted frog (*Rana pretiosa*)	Threatened (79 Fed. Reg. 51657, 51710, August 29, 2014)	Endangered	None
Marbled murrelet (*Brachyramphus marmoratus*)	Threatened (57 Fed. Reg. 45328, October 1, 1992)	Threatened	None
Northern spotted owl (*Strix occidentalis*)	Threatened(55 Fed. Reg. 26114, June 26, 1990)	Endangered	None
Streaked horned lark (*Eremophila alpestris*)	Threatened (78 Fed. Reg. 61451 61503, October 3, 2013)	Endangered	None
Yellow-billed cuckoo (*Coccyzus americanus*)	Threatened (79 Fed. Reg. 59991, October 3, 2014)	Species of Concern	None
Gray wolf (*Canis lupus*)	Endangered (43 Fed. Reg. 9607, March 9, 1978)	Endangered	None
Southern Resident killer whale DPS (*Orcinus orca*)	Endangered (70 Fed. Reg. 69903, November 18, 2005)	Endangered	Predator of adult salmon, with preferred species being Chinook salmon followed by chum salmon

Sources: USFWS 2016; WDFW 2016

Of the remaining listed species (Southern Resident killer whale and marbled murrelet), effects of existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin would be expected to be negligible for marbled murrelets (Subsection 3.5.3.1, ESA-listed Species, in the PS Hatcheries DEIS [NMFS 2014a]). However, although effects of the salmon and steelhead hatchery programs on Southern Resident killer whales are not likely substantial in general (NMFS 2012, 2016c; Subsection 3.5, Wildlife, in the PS Hatcheries DEIS [NMFS 2014a]), they are analyzed in this EIS because of their special interest to the public.

The Southern Resident killer whale is listed under the ESA as endangered and is present in marine areas in the analysis area. The species is known to expand its movement into Puget Sound particularly during the fall months and is occasionally observed in Elliott Bay (which is the outlet of the Duwamish-Green River Basin into Puget Sound) (Wiles 2016). As described in Subsection 3.5.3.1.1, Killer Whale, in the PS Hatcheries DEIS (NMFS 2014a) and references therein, Southern Resident killer whales' primary prey in inland marine waters during the summer months is adult Chinook salmon (also see Ford et al. 2016; Chasco et al. 2017), even when other salmon species are more abundant. Based on preliminary results from genetic analysis of a limited number of samples collected during killer whale feeding events, Chinook salmon are also important (at least 50 percent of the diet), to Southern Resident killer whales in Puget Sound during the winter (Michael Ford, Northwest Fisheries Science Center, email set to Tim Tynan, NMFS, January 30, 2017, regarding killer whale diets). Adult chum salmon are more important in their diet in inland waters in fall (Ford et al. 2016).

Adult hatchery-origin Chinook salmon represent 74 percent of the total number of Chinook salmon (hatchery-origin and natural-origin) returning to Puget Sound (Table 3.2-1, in the PS Hatcheries DEIS [NMFS 2014a]). There is no evidence that Southern Resident killer whales distinguish between hatchery-origin and natural-origin salmon. Therefore, it is highly likely that the hatchery-origin adult salmon (especially Chinook salmon) contribute to the diet of the whales in Puget Sound. Adults from hatchery releases have partially compensated for declines in natural-origin salmon and may have benefited Southern Resident killer whales (Chasco et al. 2017). Other salmon and steelhead are also prey items during specific times of the year, but at much less frequency than would be expected based on their relative abundances (Subsection 3.5.3.1.1, Killer Whale, in the PS Hatcheries DEIS [NMFS 2014a]).

The number of adult Chinook salmon produced by hatchery programs in the Duwamish-Green River Basin is unsubstantial relative to the total abundance of Chinook salmon present in Puget Sound and Pacific coastal marine areas. As discussed in Subsection 3.5.3.1.1, Killer Whale, in the PS Hatcheries DEIS (NMFS 2014a), Fraser River Chinook salmon stocks are an important component of the Southern Resident killer whale summer diet in the vicinity of the San Juan Islands and the western Strait of Juan de Fuca, British Columbia. Of the Chinook salmon prey in these areas from May to September, 80 to 90 percent likely originate from the Fraser River and 6 to 14 percent originate from Puget Sound rivers. Thus, during the summer months, Southern Residents forage primarily on adult Chinook salmon stocks that are entering the Strait of Juan de Fuca or the Strait of Georgia en route to spawning streams in the Fraser River system (Hanson et al. 2010).

The contribution of hatchery programs in the Duwamish-Green River Basin to the prey base for Southern Resident killer whales is likely minimal. For example, under existing conditions the 4,500,000 fall-run Chinook salmon that are released (Table 3), produce an estimated average return of 19,395 adults that are available as prey and for harvest (Tim Tynan, NMFS, email sent to Steve Leider, Fish Biologist, NMFS, February 2, 2017, regarding the number of hatchery-origin Chinook salmon from hatchery programs in the Duwamish-Green River Basin). In contrast, the estimated total annual abundance of adult Chinook salmon from Washington State and British Columbia Pacific Ocean coastal waters that is available for Southern Resident killer whales averages approximately 1,000,000 fish (Larrie LaVoy, NMFS, email sent to Tim Tynan, Fish Biologist, NMFS, January 6, 2012, regarding total abundance of adult Chinook salmon). Therefore, because fish from hatchery programs in the Duwamish-Green River Basin co-occur in Puget Sound along with many other hatchery-origin and natural-origin salmon originating from other Puget Sound river basins, the Fraser River, Columbia River, and Washington Coast, it is unlikely that fish from the hatchery programs form a substantial part of the diet of Southern Resident killer whales.

In summary, considering all adult natural-origin and hatchery-origin salmon and steelhead in Puget Sound that are part of the food base for the Southern Resident killer whale, the contributions of adult hatchery-origin salmon and steelhead from the Duwamish-Green River Basin under existing conditions have had a negligible positive effect on the diet, survival, distribution, and listing status Southern Resident killer whales, primarily because adults returning from the hatchery programs (especially Chinook salmon) would represent a small part of the Southern Resident killer whale food base provided by the total number of hatchery-origin and natural-origin salmon and steelhead available from throughout the greater Puget Sound, the Strait of Georgia, and Pacific Coast area, particularly during the fall months.

3.5 Socioeconomics

This subsection describes existing socioeconomic conditions that may be affected by the alternatives that are analyzed in Subsection 4.5, Socioeconomics. Socioeconomics is the study of the relationship between economics and social interactions with affected regions, communities, and user groups. In addition to providing fish for harvest for commercial, recreational, and tribal ceremonial and subsistence purposes, hatchery programs directly affect socioeconomic conditions in areas where hatchery facilities operate. Hatchery programs generate economic activity (personal income and jobs) by providing employment opportunities and through the local procurement of goods and services for hatchery operations (e.g., fish food and technical assistance). Described in this subsection are socioeconomic conditions associated with the seven existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin (Table 1). Included are hatchery program costs and employment, economic values of the commercial harvest and recreational fishing effort, and the contribution to the regional economy associated with the commercial and recreational fisheries.

Commercial and recreational salmon and steelhead fisheries in marine and freshwater areas of Puget Sound are co-managed by the Puget Sound treaty tribes (described in Subsection 3.6, Native American Tribes of Concern [Environmental Justice]) and WDFW, under *United States v. Washington*. As described in Subsection 1.7.6, *United States v. Washington*, *United States v. Washington* is the Federal court proceeding that enforces and allocates harvest between the state and treaty tribes while addressing reserved treaty fishing rights with regard to salmon and steelhead returning to Puget Sound. Native American tribes having treaty fishing rights are designated as user groups of concern in Subsection 3.6.3, Native American Tribes of Concern.

For this socioeconomic analysis, indicators of socioeconomic conditions evaluated include ex-vessel values to commercial fishermen, trip-related expenditures by recreational fishermen, hatchery program expenditures, and direct and indirect employment and personal income associated with hatchery operations and affected fisheries. Values are not rounded to aid the reader in finding corresponding numbers between tables and text. The use of unrounded numbers, however, should not be interpreted as suggestive of unusually high levels of precision in the estimates. All numbers presented represent a reasonable estimate of the underlying values. Existing conditions are estimated at the basin (local) and regional (Puget Sound-wide) scales (the socioeconomic analysis area, as described below). For this EIS, existing conditions at the regional scale are estimated in the context of all salmon and steelhead fishing activity, using the 2010 to 2014 time frame, which is the most recent 5-year period for which complete data are available. Detailed information on methods applied in analyzing the socioeconomic resource is presented in Appendix B, Socioeconomics.

The analysis area for this socioeconomic evaluation is the geographic area where effects of the Proposed Action would occur (Subsection 1.4, Project and Analysis Areas), including the Duwamish-Green River Basin (which is in King County) and marine waters in the United States portion of Puget Sound. The socioeconomic analysis area includes rivers and marine areas in nine Puget Sound counties that are organized in three subregions: North Puget Sound (Whatcom and Snohomish Counties), Strait of Juan de Fuca (Clallam and Jefferson Counties), and South Puget Sound. In addition to King County, the South Puget Sound subregion also includes Pierce, Thurston, Mason, and Kitsap Counties. Communities and ports in the South Puget Sound subregion that are affected by the commercial, recreational, and tribal ceremonial and subsistence fisheries in the Duwamish-Green River Basin include the ports, cities, and communities of Seattle, Tacoma, Olympia, Shelton, Poulsbo, Puyallup, and Bremerton. Rural communities in South Puget Sound (e.g., Orting) are also affected by fisheries harvest, including both non-treaty and treaty fishery activities. The PS Hatcheries DEIS (NMFS 2014a) identifies smaller Puget Sound communities where fishing activities provide economic values and benefits.

This socioeconomic information is also used to characterize the environmental justice affected environment (Subsection 3.6, Environmental Justice). Therefore, data and tables provided in this socioeconomic subsection may also be referred to in Subsection 3.6, Environmental Justice, to reduce redundancy.

3.5.1 Fisheries Affected by the Hatchery Programs

This subsection provides a description of the commercial harvest and recreational effort associated with salmon and steelhead produced by existing hatchery programs in the Duwamish-Green River Basin, including numbers of fish commercially harvested and recreational effort in terms of fishing trips. When juveniles released from the hatchery programs in the Duwamish-Green River Basin return, they are caught as adults in marine and fresh waters of Puget Sound in tribal and non-tribal commercial fisheries, recreational fisheries, and tribal ceremonial and subsistence fisheries.

In addition to supporting tribal commercial and non-tribal recreational fisheries in fresh waters of the Duwamish-Green River Basin, returns from the hatchery programs contribute to the tribal and non-tribal harvests of salmon and steelhead in the marine waters of the Duwamish estuary, Elliott Bay, south Puget Sound subregion, and marine waters in other subregions of Puget Sound. Because commercial and recreational fisheries in nearby marine waters (e.g., Catch Areas 10 and 11 adjacent to the Duwamish-Green River estuary) focus on other Puget Sound stocks (not just fish from the Duwamish-Green River Basin or from other parts of the south Puget Sound subregion), hatchery production in the Duwamish-Green River Basin is most influential on harvests in the south Puget Sound subregion and has unsubstantial effects on fisheries in these nearby marine areas (PS Hatcheries DEIS [NMFS 2014a]).

Commercial Fisheries (Tribal and Non-tribal): Commercial fishing for salmon and steelhead from hatchery programs in the Duwamish-Green River Basin is important for both tribal and non-tribal fishermen. Seattle is the main King County port where fish are sold and processed.

Estimates of the numbers of salmon and steelhead from hatchery production the Duwamish-Green River Basin harvested by commercial fishermen in Puget Sound waters are presented in Table 22. The total annual commercial catch of Chinook salmon, coho salmon, chum salmon, and steelhead in Puget Sound waters is estimated to be 139,292 fish, with 91 percent of the fish caught in tribal fisheries and 9 percent of the fish caught in non-tribal fisheries (Table 22). There is no non-tribal commercial harvest in the Strait of Juan de Fuca subregion. Over 98 percent of the total commercial harvest occurs in the South Puget Sound subregion, and over 99 percent of that harvest occurs in King County (Table 22). Within King County, 136,353 salmon and steelhead are commercially harvested, with 91 percent in tribal fisheries and 9 percent in non-tribal fisheries (Table 22).

Table 22. Catch and economic contributions from hatchery programs in the Duwamish-Green River Basin to salmon and steelhead commercial and recreational fisheries in the socioeconomic analysis area under existing conditions.

Subregion/ Port County	Commercial Fisheries						Recreational Fisheries (Marine and Freshwater)	
	Tribal		Non-tribal		Total			
	Number of Fish Caught	Ex-vessel Value ($)	Number of Fish Caught	Ex-vessel Value ($)	Number of Fish Caught	Ex-vessel Value ($)	Number of Trips	Trip Expenditures ($)
North Puget Sound								
Whatcom [1]	369	2,007	350	1,766	719	3,773	1,367	240,348
Snohomish [2]	77	488	76	482	153	969	8,837	1,553,732
Subtotal	**446**	**2,495**	**426**	**2,248**	**872**	**4,,743**	**10,204**	**1,794,079**
South Puget Sound								
King [3]	124,124	797,899	12,229	61,981	136,353	859,880	23,613	4,151,866
Pierce [4]	385	2,499	--	--	385	2,499	3,638	639,637
Thurston [5]	100	1,334	--	--	100	1,334	--	--
Kitsap [6]	54	562	--	--	54	562	1,433	251,952
Subtotal	**124,663**	**802,295**	**12,229**	**61,981**	**136,892**	**864,276**	**28,684**	**5,043,255**
Strait of Juan de Fuca								
Clallam [7]	1,255	15,497	--	--	1,255	15,487	14,043	2,469,057
Jefferson [8]	273	1,352	--	--	273	1,352	925	162,635
Subtotal	**1,528**	**16,849**	**--**	**--**	**1,528**	**16,849**	**14,968**	**2,631,692**
TOTAL	**126,637**	**821,639**	**12,655**	**64,229**	**139,292**	**885,868**	**53,856**	**9,469,026**

Source: Appendix B, Socioeconomics

[1] Includes landing locations of Bellingham/Blaine (Catch Areas 7/7A/7B).

[2] Includes landing locations of Marysville/Everett.

[3] Includes landing locations of Seattle (Catch Area 10).

[4] Includes landing locations of Tacoma.

[5] Includes landing locations of Shelton/Olympia.

[6] Includes landing locations of Bremerton and Kingston.

[7] Includes landing locations of Neah Bay, Sekiu, and Sequim.

[8] Includes landing locations of Port Townsend.

All dollar values are reported in 2015 dollars.

The total ex-vessel value[17] of commercial harvests associated with salmon and steelhead produced by the hatchery programs in the Duwamish-Green River Basin is $885,868, with tribal fisheries accounting for 93 percent of this value and non-tribal fisheries accounting for 7 percent of this value (Table 22). In the South Puget Sound subregion, over 99 percent of the ex-vessel value occurs at ports within King County (Table 22).

From an analysis conducted for the PS Hatcheries DEIS (NMFS 2014a) for the years 2002 to 2006, most of the salmon and steelhead harvested for tribal and non-tribal fisheries in the South Puget Sound subegion are chum salmon (49 percent), followed by coho salmon (27 percent), Chinook salmon (17 percent), sockeye salmon (5 percent), pink salmon (1 percent), and steelhead (less than 1 percent). Of the salmon and steelhead produced at hatcheries in the Duwamish-Green River Basin, Chinook salmon and steelhead have the greatest contribution to Puget Sound fisheries, followed by coho salmon and chum salmon (PS Hatcheries DEIS [NMFS 2014a]). Ceremonial and subsistence fisheries conducted by treaty tribes are included in the tribal commercial catch. Subsection 3.6, Environmental Justice, describes ceremonial and subsistence fisheries within the Duwamish-Green River Basin.

Recreational Fisheries: There are a number of opportunities for recreational fishing associated with the Duwamish-Green River Basin. As described in the PS Hatcheries DEIS (NMFS 2014a), recreational salmon fishing occurs in the basin up to the City of Tacoma's diversion dam (RM 61), but is more concentrated in the lower river up to RM 34. Much of the hatchery production that supports these recreational fisheries originates at the Soos Creek Hatchery (PS Hatcheries DEIS [NMFS 2014a]), which produces fall-run Chinook salmon, coho salmon, and summer-run steelhead (Table 1).

Recreational fishing for steelhead, Chinook salmon, coho salmon, and chum salmon occurs in the Duwamish-Green River Basin. Since the early 1990s, recreational fishing for steelhead has been confined to hatchery-origin steelhead, resulting from the implementation of conservation measures to protect listed natural-origin steelhead. All natural-origin steelhead (not adipose fin clipped) must be released, and two hatchery-origin steelhead can be retained. In addition, listed natural-origin Chinook salmon caught while recreational fishing in fresh waters of the Duwamish-Green River Basin must be released, and Chinook salmon that are caught and kept must be at least 22 inches in length. There are also size restrictions (minimum size of 12 inches) for unlisted coho salmon and chum salmon that are caught and kept, with a daily maximum limit of six fish (three adults).

[17] The term ex-vessel value refers to the price (income) that fishermen receive for the fish "at the dock."

Recreational fisheries targeting salmon and steelhead produced from the hatchery programs in the Duwamish-Green River Basin result in an estimated 53,856 trips (Table 22). These trips generate an estimated $9,469,026 in trip-related expenditures (Table 22). Most of these trips originate from ports and launch areas in the South Puget Sound subregion (53 percent), followed by those from ports and launch areas in the Strait of Juan de Fuca subregion (28 percent), and from ports and launch areas in the North Puget Sound subregion (19 percent) (Table 22). Recreational fishing trips originating from ports and launch areas in King County (23,643 trips) account for 82 percent of all recreational fishing trips originating from the South Puget Sound subregion that target salmon and steelhead produced from the hatchery programs (Table 22).

3.5.2 Hatchery Operations

The seven existing hatchery programs that produce salmon and steelhead in the Duwamish-Green River Basin use a number of primary hatchery facilities (e.g., Soos Creek Hatchery, Keta Creek Complex), rearing ponds, and net pens (Table 1). Operating the hatchery programs directly affects socioeconomic conditions by providing employment opportunities and wages and also by creating local demand for the procurement of goods and services (e.g., fish food and technical assistance) needed for hatchery operations, and indirectly by the re-spending income in the local and regional economy. Estimates of the contribution of hatchery operations to local and regional economies are based on ongoing operation and maintenance costs (Appendix B, Socioeconomics). Annual operations and maintenance expenditures associated with the existing salmon and steelhead programs are estimated at approximately $1.05 million[18], excluding the costs of hatchery operations at the Marine Technology Center, which is primarily used for educational purposes. Hatchery operations also contribute to economic activity in more distant areas (e.g., Seattle) where more goods and services are available.

The total number of full-time equivalent (FTE) jobs associated with the seven existing salmon and steelhead hatchery programs is estimated at 12.3 jobs, including 15 seasonal employees at the Keta Creek Complex.

3.5.3 Regional and Local Economies

The commercial and recreational fisheries that target salmon and steelhead produced by hatchery programs in the Duwamish-Green River Basin generate economic activity characterized by employment (jobs) and personal income. Commercial harvest and recreational fishing (trips) and

[18] Estimates of operations and maintenance expenditures are from the HGMPs for the six existing hatchery programs (Muckleshoot Indian Tribe 2014b; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014c, 2015) and do not include the Marine Technology Center program (WDFW 2014b).

associated employment and personal income are distributed within and between the three subregions constituting the analysis area (Table 22 and Table 23). The eight key port locations within each of these subregions and counties where fish are landed are 1) Bellingham/Blaine (Whatcom County); 2) Marysville/Everett (Snohomish County); 3) Seattle (King County); 4) Tacoma (Pierce County); 5) Shelton/Olympia (Mason/Thurston Counties); 6) Bremerton and Kingston (Kitsap County); 7) Neah Bay, Sekiu, and Sequim (Clallam County); and 8) Port Townsend (Jefferson County), with Seattle as the key port location in King County.

Table 23. Contributions of hatchery operations in the Duwamish-Green River Basin and affected commercial and recreational fisheries to jobs and personal income in the socioeconomic analysis area under existing conditions.

	Hatchery Operations[1]		Fisheries				Total Hatchery Operations and Fisheries	
			Commercial		Recreational			
Subregion/ Port County	**Number of Jobs[2]**	**Personal Income[3] ($)**	**Number of Jobs**	**Personal Income[4] ($)**	**Number of Jobs**	**Personal Income[4] ($)**	**Number of Jobs**	**Personal Income[4] ($)**
North Puget Sound								
Whatcom	--	--	0.1	6,254	5.2	254,782	5.3	261,036
Snohomish	--	--	<0.1	1,607	26.8	1,647,046	26.8	1,648,653
Subtotal	**--**	**--**	**0.2**	**7,860**	**32.0**	**1,909,689**	**32.2**	**1,917,549**
South Puget Sound								
King	18.1	$868,856	18.0	1,425,064	55.5	4,401,008	91.6	5,826,072
Pierce	--	--	0.1	4,142	11.8	678,053	11.9	682,195
Thurston	--	--	<0.1	2,211	--	--	<0.1	2,211
Kitsap	--	--	<0.1	932	4.8	267,084	4.8	268,016
Subtotal	**18.1**	**$868,856**	**18.1**	**1,432,349**	**72.1**	**5,346,144**	**90.2**	**6,778,493**
Strait of Juan de Fuca								
Clallam	--	--	0.6	25,683	62.4	2,617,344	63.0	2,643,027
Jefferson	--	--	0.1	2,241	4.6	172,402	4.7	174,643
Subtotal	**--**	**--**	**0.7**	**27,924**	**67.0**	**2,817,670,**	**67.7**	**2,845,594**
TOTAL	**18.1**	**$868,856**	**18.9**	**1,468,133**	**171.2**	**10,037,720**	**190.1**	**11,505,853**

Source: Estimates of jobs and personal income derived by TCW Economics using the Puget Sound economic impact spreadsheet model (Appendix B, Socioeconomics).

[1] All hatchery facilities in the Duwamish/Green River Basin are located in King County. Although some hatchery operational expenditures likely occur in nearby counties, these effects are assumed to be unsubstantial, especially because Seattle also is located in King County. For the purposes of this analysis, some hatchery-related expenditures by WDFW would be assigned to "headquarters," which is located in Olympia (Thurston County).

[2] Jobs in this table are in full time equivalents (FTEs).

[3] Includes wages and salaries.

[4] Includes wages and salaries and other sources of income.

All dollar values are reported in 2015 dollars.

Economic activity generated by commercial and recreational fishing is concentrated within certain sectors of the regional economy. In addition to the fish harvesting sector, commercial fisheries affect seafood product preparation and packing, including the canning and curing of seafood and preparation of fresh or frozen fish or seafood. Wholesaling and restaurant sectors also are affected. Recreational fisheries contribute to local economies through the purchase of fishing-related goods and supplies and by the retention of local services, such as outfitter and guiding services. Sectors particularly affected by recreational fishing activities include food services, eating and drinking establishments, lodging, recreation services, and fueling stations. Expenditures on fishing-related goods and services by fishermen contribute to both local and non-local businesses.

Hatchery operations for the existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin generate (directly and indirectly) an estimated 18.1 jobs and $868,856 in personal income that contribute to the regional economy (Table 23). These effects occur almost entirely in King County because that is where the hatcheries are located.

The commercial harvest of salmon and steelhead occurs in fresh and marine waters of Puget Sound and generates (directly and indirectly) an estimated 18.9 jobs and $1,468,133 in personal income (Table 23). The vast majority of these jobs and personal income (96 percent) occur within King County (Table 23). However, many of the jobs supported by commercial fishing for salmon are part-time and seasonal.

Recreational fishing activities targeting salmon and steelhead produced by hatchery programs in the Duwamish-Green River Basin generate (directly and indirectly) an estimated total of 171.2 jobs and $10,037,720 in personal income throughout Puget Sound (Table 23). Most jobs and income generated by recreational fishing occur in the South Puget Sound subregion (42 percent of the jobs and 53 percent of the income), followed by in the Strait of Juan de Fuca subregion (36 percent of the jobs and 28 percent of the income), and the North Puget Sound subregion (22 percent of the jobs and 19 percent of the income) (Table 23). Overall, about 42 percent of the jobs and 44 percent of the personal income generated by recreational fishing occur in King County (Table 23).

Local economies that are most affected by hatchery operations and fisheries associated with the hatchery programs in the Duwamish-Green River Basin are those that are in the river basin (e.g., Seattle, Kent, Auburn, Black Diamond). The secondary benefits of hatchery operations and fisheries (e.g., purchase of fishing and hatchery supplies) occur throughout the Puget Sound region, but are concentrated in the South Puget Sound subregion, King County in particular, where all of the hatchery operations occur and most of the economic activity generated by affected commercial and recreational fisheries takes place.

The average total number of fish harvested commercially (139,292 fish) and ex-vessel value ($885,868) (Table 22) associated with commercial fishing for salmon and steelhead produced by hatcheries in the Duwamish-Green River Basin represent 3.2 percent of the harvest and 4.2 percent of the total ex-vessel value associated with all salmon and steelhead commercially harvested in marine and fresh waters of Puget Sound (Table 24). In addition, the number of recreational fishing trips (53,856) and trip-related expenditures ($9,469,026) (Table 22) associated with recreational fishing for salmon and steelhead produced by the hatcheries represent 3.6 percent of all trips and total trip-related expenditures associated with all recreational fishing for salmon and steelhead in marine and fresh waters of Puget Sound (Table 24).

Table 24. Economic values associated with all salmon and steelhead commercial and recreational fisheries, affected jobs, and personal income in the socioeconomics analysis area under existing conditions (averages from 2010 to 2014).

Commercial Fisheries				Recreational Fisheries			
Number Harvested	**Ex-vessel Value ($)**	**Number of Jobs**	**Personal Income ($)**	**Number of Trips**	**Trip-related Expenditures ($)**	**Number of Jobs**	**Personal Income ($)**
4,414,951	$21,010,062	599	$31,933,084	1,502,267	$265,830,434	3,536	$215,075,942

Source: Appendix B, Socioeconomics

The average total number of jobs (18.9 jobs) and personal income ($1,468,133) (Table 23) associated with commercial fishing for salmon and steelhead produced by hatcheries in the Duwamish-Green River Basin represent 3.2 percent of the all jobs and 4.6 percent of the total personal income associated with all salmon and steelhead commercially harvested in marine and fresh waters of Puget Sound (Table 24). In addition, the average total number of jobs (171.2 jobs) and personal income ($10,037,720) (Table 23), associated with recreational fishing for salmon and steelhead produced by the hatcheries represents 4.8 percent of all jobs and 4.7 percent of the total personal income associated with all recreational fishing for salmon and steelhead in marine and fresh waters of Puget Sound (Table 24).

In summary, considering all effects on socioeconomics from the hatchery programs in the Duwamish-Green River Basin under existing conditions described above, the income from tribal commercial and non-tribal recreational fisheries and hatchery operations, and the contributions to regional and local economies, have had a low positive effect across the socioeconomic analysis area overall, with the greatest benefits to tribal commercial fisheries and non-tribal recreational fisheries in the South Puget

Sound subregion, particularly in King County. However, in some of the more remote areas and communities of the Duwamish-Green River Basin in the South Puget Sound subregion, the effect would be greater because some local economies are more economically dependent on the direct and indirect economic effects of the hatchery programs.

3.6 Environmental Justice

This subsection was prepared in compliance with Presidential Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, dated February 11, 1994, and Title VI of the Civil Rights Act of 1964.

Executive Order 12898 (see 59 Fed. Reg. 7629, February 16, 1994) states that Federal agencies shall identify and address, as appropriate "…disproportionately high and adverse human health or environmental effects of [their] programs, policies and activities on minority populations and low-income populations…." While there are many economic, social, and cultural elements that influence the viability and location of such populations and their communities, certainly the development, implementation and enforcement of environmental laws, regulations, and policies can have impacts. Therefore, Federal agencies, including NMFS, must ensure fair treatment, equal protection, and meaningful involvement for minority populations and low-income populations as they develop and apply the laws under their jurisdiction.

Both Executive Order 12898 and Title VI address persons belonging to the following target populations:

- Minority – all people of the following origins: Black, Asian, American Indian and Alaskan Native, Native Hawaiian or Other Pacific Islander, and Hispanic[19]

- Low income – persons whose household income is at or below the U.S. Department of Health and Human Services poverty guidelines.

Definitions of minority and low-income areas were established on the basis of CEQ's *Environmental Justice Guidance under the National Environmental Policy Act* of December 10, 1997. This CEQ guidance states that "minority populations should be identified where either (a) the minority population of the affected area exceeds 50 percent or (b) the population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other

[19] Hispanic is an ethnic and cultural identity and is not the same as race.

appropriate unit of geographical analysis." The CEQ further adds that "[t]he selection of the appropriate unit of geographical analysis may be a governing body's jurisdiction, a neighborhood, a census tract, or other similar unit that is chosen so as not to artificially dilute or inflate the affected minority population."

The CEQ guidance does not specifically state the percentage considered meaningful in the case of low-income populations. For this EIS, the assumptions set forth in the CEQ guidelines for identifying and evaluating impacts on minority populations are used to identify and evaluate impacts on low-income populations. More specifically, potential environmental justice impacts are assumed to occur in an area if the percentages of minorities and percentage below poverty level are markedly greater than the percentages of minorities and percentage below poverty level in their state as a whole (i.e., Washington). Similarly, potential environmental justice impacts are assumed to occur in an area if the per capita income is markedly less than the per capita income for the state as a whole.

The analysis area for environmental justice includes minority and low-income communities that may be affected directly, indirectly, or cumulatively by implementing the project alternatives and is the same as for socioeconomics and includes the geographic area where the Proposed Action would occur (Subsection 1.4, Project and Analysis Areas). This subsection describes communities and groups within the entire environmental justice analysis area and three multi-county subregions (Figure 3) that may be affected by the alternatives. The three subregions are the North Puget Sound subregion (consisting of Whatcom and Snohomish Counties); the South Puget Sound subregion (consisting of King, Kitsap, Pierce, and Thurston Counties); and the Strait of Juan de Fuca subregion (consisting of Clallam and Jefferson Counties) The salmon and steelhead hatchery programs analyzed in this EIS raise and release fish in the Duwamish-Green River Basin in King County. Fisheries harvesting salmon and steelhead produced in these hatchery programs occur primarily in King County in the South Puget Sound subregion, to a much lesser extent in counties in the Strait of Juan de Fuca subregion, and minimally in the North Puget Sound subregion (Subsection 3.5, Socioeconomics). Catch data are reported by designated catch area as described by WDFW (2016b). Catch Area 10 includes the Duwamish-Green River Basin, as well as Seattle north to Edmonds and east to Bainbridge Island.

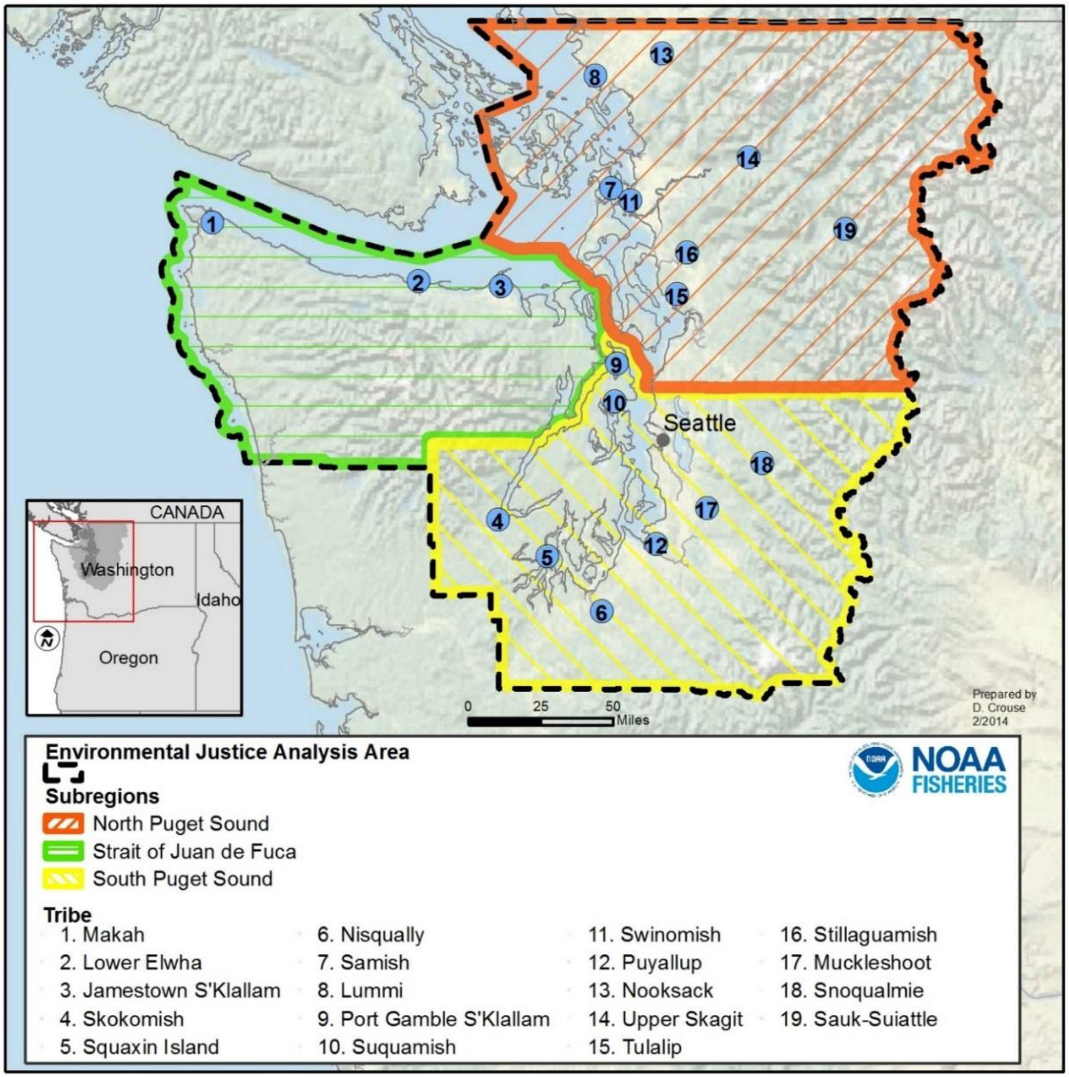

Figure 3. Three subregions and locations of federally recognized Puget Sound Indian tribes in the environmental justice analysis area. Note the Samish and Snoqualmie tribes are federally recognized, but do not have federally recognized treaty fishing rights.

For the analysis of environmental justice effects, socio-demographic data were evaluated at the county level to identify areas (or communities) of concern. For consistency with the socioeconomic analysis presented in Subsections 3.5 and 4.5, Socioeconomics, county-level information is organized according to the subregions described above (North Puget Sound, South Puget Sound, and Strait of Juan de Fuca) (Figure 3). In addition to the geographic scale of analysis, the environmental justice evaluation also focuses on different user groups that may be affected by the hatchery programs. For this analysis, these groups include commercial fish harvesters and processors, recreational anglers and support businesses, and Native American tribes in the analysis area that participate in both commercial and subsistence/ceremonial fishing activities and that operate salmon hatcheries.

3.6.1 Communities of Concern

Six counties are communities of concern because their per capita income is below or their poverty rate is above threshold levels, or because criteria for minority groups are exceeded (Table 25). One county in the North Puget Sound subregion and one county in South Puget Sound subregion are communities of concern based on low-income criteria and minority criteria (Whatcom and Clallam Counties), and four other counties are communities of concern based only on minority criteria (Snohomish, King, Pierce, and Jefferson Counties) (Table 25). Kitsap and Thurston Counties are not communities of concern based on any income or minority group criteria.

Table 25. Identification of environmental justice communities of concern (counties) by subregion and county, based on population size, percent minority, per capita income, and percent below poverty level for counties in the environmental justice analysis area and Washington State.

Subregion and County	Minority				Income		Population Size
	Percent Black	Percent Native American	Percent Asian and Islanders	Percent Hispanic	Per Capita Income ($)	Percent Below Poverty Level	
North Puget Sound							
Snohomish County	3.2	1.6	11.0	9.9	32,542	9.3	772,501
Whatcom County	1.2	3.2	4.7	9.2	27,223	14.4	212,284
South Puget Sound							
King County	6.8	1.1	17.8	9.5	41,664	9.8	2,117,125
Kitsap County	3.0	1.8	6.4	7.5	32,063	9.9	260,131
Pierce County	7.4	1.7	8.3	10.5	28,824	12.4	843,954
Thurston County	3.5	1.7	7.1	8.6	29,741	12.2	269,536
Strait of Juan de Fuca							
Clallam County	1.0	5.6	1.9	6.0	27,000	15.6	72,650
Jefferson County	1.0	2.3	2.0	3.8	28,593	11.9	30,880
Washington State	**4.1**	**1.9**	**9.1**	**12.4**	**31,762**	**12.2**	**7,170,351**

Source: U.S. Bureau of Census 2016

Shading of cells represents values that are meaningfully exceeded (by 10 percent or greater) those of the reference population (Washington State), thus indicating environmental justice communities of concern.

King County, the county in which the Duwamish-Green River Basin and the hatchery programs are located, is an environmental justice community of concern because the percentages of two minority populations meaningfully exceed statewide averages, not because of per capita income or poverty rates. In King County, 6.8 percent of the population is Black compared to 4.1 percent for the state as a whole, and 17.8 percent of the population is Asian and Pacific Islanders, compared to 9.1 percent for the state as a whole (Table 25). The environmental justice effect of the hatchery programs in the Duwamish-Green River Basin to the people in King County is represented by the economic and cultural value of the salmon and steelhead harvested. Of the fish produced by the hatchery programs in the Duwamish-Green River Basin, an average of 136,353 fish (98 percent) are harvested in King County by non-tribal and tribal commercial fishermen (Table 22). Commercial fishing activities in all of the other communities of concern (counties) combined, are responsible for harvesting only 2 percent of the fish produced by the hatchery programs, with the greatest portion of that harvest occurring in the Strait of Juan de Fuca subregion (Table 22). Recreational fishing trips and related expenditures associated with fish produced by the hatchery programs are also greatest in King County (about 44 percent), followed by 26 percent in Clallam County and 16 percent in Snohomish County (Table 22).

3.6.2 Non-tribal User Groups of Concern

As described in Subsection 3.4, Environmental Justice, in the PS Hatcheries DEIS (NMFS 2014a), hatchery production of salmon and steelhead in Puget Sound and associated harvests may affect potential user groups of concern (commercial and recreational fishermen). Socio-demographic data is considered in determining if a user group is an environmental justice user group of concern. Because socio-demographic data specific to non-tribal user groups of concern are generally not available, the analysis of non-tribal user groups focuses on counties associated with the ports where landings from non-tribal commercial fishing occurs (Table 22). Based on data available for the ports where fish from non-tribal commercial fisheries are landed, three ports in three counties meet minority and/or low-income criteria found in Table 25 and are environmental justice groups of concern. These are Bellingham in Whatcom County and Marysville/Everett in Snohomish County in the North Puget Sound subregion, and Seattle in King County in the South Puget Sound subregion (Table 25). Ports in counties in which no landings of fish from non-tribal commercial fisheries occur (i.e., Clallam and Jefferson Counties) (Table 22) are not environmental justice non-tribal user groups of concern.

Although recreational fishermen catch substantial numbers of fish produced by the hatchery programs in the Duwamish-Green River Basin, and recreational fishing leads to substantial trip-related expenditures (Table 22), based on socio-demographic data, recreational fishermen are not an environmental justice group of concern. As described in Subsection 3.4.1.3, Approach to Identifying Non-tribal User Groups of Concern, in the PS Hatcheries DEIS (NMFS 2014a), the assessment of recreational fishermen as a potential user group of concern focuses on two minority categories (percentage of non-white and Hispanic) and income thresholds to determine low-income status. The assessment is conducted using available statewide data because comprehensive socio-demographic data are not available at the local (county) or subregion level. As shown in Table 26, the percentages of Washington's recreational fishermen that are non-white or Hispanic and the percentage of Washington recreational fishermen in low-income households are less than the percentages for the overall statewide population. Thus, recreational fishermen are not an environmental justice group of concern, and recreational fishermen are not analyzed further in the EIS for environmental justice.

Table 26. Comparison of demographic characteristics of recreational fishermen in Washington State compared to the statewide population.

Category	Race or Ethnicity		Annual Household Income	
	Percentage Non-white	Percentage Hispanic	Percentage <$10,000	Percentage $10,000-$20,000
Washington recreational fishermen	4	3	2	3
Washington statewide population	14	7	3	6

Source: USFWS 2006

Relatively few of the fish produced by hatchery programs in the Duwamish-Green River Basin are harvested by non-tribal commercial fishermen in the environmental justice analysis area. Of the 12,655 fish caught by non-tribal commercial fishermen, nearly all (97 percent, or 12,229 fish) are associated with the ports in Seattle (Table 22), with the remainder (3 percent, or 426 fish) associated with ports in the North Puget Sound subregion. Over the past 10 years an average of 12,229 fish produced by the hatchery programs have been harvested by non-tribal commercial fishermen within the South Puget Sound subregion (Catch Area 10), generating $61,981 in ex-vessel value (Table 22).

3.6.3 Native American Tribes of Concern

The EPA guidance regarding environmental justice extends beyond statistical threshold analyses to consider explicit environmental justice effects on Native American tribes (EPA 1998). Federal duties under Executive Order 12898, the presidential directive on government-to-government relations (Subsection 1.7.4, Executive Order 12898), and the trust responsibility to Indian tribes (Subsection 1.7.8, The Federal Trust Responsibility), may merge when the action proposed by another Federal agency or the EPA potentially affects the natural or physical environment of a tribe. The natural or physical environment of a tribe may include resources reserved by treaty or lands held in trust; sites of special cultural, religious, or archaeological importance, such as sites protected under the National Historic Preservation Act or the Native American Graves Protection and Repatriation Act; and other areas reserved for hunting, fishing, and gathering (*usual and accustomed* areas, which may include “ceded” lands that are not within reservation boundaries). Potential effects of concern may include ecological, cultural, human health, economic, or social impacts when those impacts are interrelated to impacts to the natural or physical environment (EPA 1998).

Of the 17 treaty tribes with adjudicated fishing rights pursuant to pursuant to *United States v. Washington* within the environmental justice analysis area (Figure 3), the Muckleshoot Indian Tribe and Suquamish Tribe are most directly associated with the hatchery programs in the Duwamish-Green River Basin. The environmental justice evaluation for tribes of concern includes:

- Ceremonial and subsistence uses
- Tribal commercial fisheries
- Economic value to tribes from hatchery operations

Ceremonial and Subsistence Uses: Tribal ceremonial and subsistence uses pertain to fish that are caught non-commercially by members of Puget Sound treaty tribes for purposes of maintaining cultural viability and providing a valuable food resource, among other traditional foods, in tribal ceremonies (Box 3-1). Examples of ceremonies that use traditional foods include winter ceremonies, first salmon ceremonies (Amoss 1987), naming ceremonies, giveaways, feasts, and funerals (Meyer Resources Inc. 1999). Subsistence refers to ways in which Native Americans use environmental resources like salmon and steelhead to meet the nutritional needs of tribal members.

Members of the Puget Sound treaty tribes prioritize their ceremonial and subsistence needs over commercial sales. Tribes may fish for ceremonial and subsistence uses when there are no concurrent commercial fisheries, and may use some of their commercial harvest for ceremonial and subsistence purposes. Many tribes feel their subsistence needs are not met by the current abundances of natural-origin and hatchery-origin fish (W. Beattie, pers. comm., NWIFC, Conservation Planning Coordinator, April 6, 2010).

As described in Subsection 3.5, Socioeconomics, salmon fishing has been a focus for tribal economies, cultures, lifestyles, and identities for many millennia (Gunther 1950). These activities continue to be important today, both economically and for subsistence and ceremonial purposes (Stay 2012; NWIFC 2013). The Muckleshoot Indian Tribe and Suquamish Tribe or their representatives work with WDFW to develop fishing plans that target salmon and steelhead produced by the hatchery programs in the Duwamish-Green River Basin. Although the Duwamish Tribe is not a federally-recognized tribe, nor does it have treaty fishing rights, the Duwamish Tribe’s ancestral lands include the Duwamish River watershed (Daniell et al. 2013). Adults returning from hatchery programs in the Duwamish-Green

River Basin are used for ceremonial and subsistence purposes by Puget Sound treaty tribes, particularly the Muckleshoot Indian Tribe and Suquamish Tribe, providing substantial benefits because of the value of salmon and steelhead to the cultural integrity of the tribes.

Box 3-1. Why are Salmon and Steelhead Important to Puget Sound Treaty Tribes?

Salmon and steelhead are important to Puget Sound treaty tribes for many reasons. Salmon fishing has been a focus for tribal economies, cultures, lifestyles, and identities for over 1,000 years. Beyond generating jobs and income for contemporary commercial tribal fishers, salmon are regularly eaten by individuals and families, and are served at gatherings of elders at traditional dinners and other ceremonies. To Indian tribes, salmon are a core symbol of tribal and individual identity. The survival and well-being of salmon are seen as inextricably linked to the survival and well-being of Indian people and their cultures. Salmon evoke sharing, gifts from nature, responsibility to the resource, and connection to the land and the water. Puget Sound treaty tribes use salmon in various ways, including personal and family consumption, informal and formal distribution and community sharing, and ceremonial uses.

Salmon are strongly associated with the use and knowledge of water, use and knowledge of appropriate harvesting techniques, and knowledge of traditional processing techniques. Salmon facilitate the transfer of tribal fishing culture to young tribal members. This education includes teaching young tribal members to use traditional and modern methods of fishing and to cook and preserve salmon.

Tribal Commercial Fisheries: Puget Sound treaty tribes harvest salmon and steelhead in commercial fisheries, and are entitled to up to 50 percent of the available harvest at available and accustomed grounds and stations (pursuant to *United States v. Washington*) (Subsection 1.7.6, *United States v. Washington*). An average of 126,637 salmon and steelhead produced by hatchery programs in the Duwamish-Green River Basin are harvested in tribal commercial fisheries in freshwater and marine areas, and these fish have a total ex-vessel value of $821,639 (Table 22). Over 98 percent of this commercial harvest and ex-vessel value occurs in the South Puget Sound subregion, 1 percent occurs in the Strait of Juan de Fuca subregion, and less than 1 percent occurs in the North Puget Sound subregion (Table 23). Of the harvest in the South Puget Sound subregion, over 99 percent occurs in King County, which is where the Duwamish-Green River Basin and the hatchery programs are located. These fish provide a substantial benefit to Puget Sound treaty tribes, particularly the Muckleshoot Indian Tribe and Suquamish Tribe.

Economic Value to Tribes from Hatchery Operations: As described in Subsection 3.4.2.3, Economic Value to Tribes from Harvest and Hatchery Operations (PS Hatcheries DEIS [NMFS 2014a]), operation of tribal hatcheries provides personal income to tribal members, and tribes receive funds for routine operations (i.e., fish food and other supplies, administration, and required services such as mass-marking). The facilities associated with the Keta Creek Hatchery are operated primarily by the Muckleshoot Indian Tribe (although the Squamish Tribe and Muckleshoot Indian Tribe operate facilities associated with the Keta Creek coho salmon hatchery program) (Table 1). The benefits to these tribes include more than five full time jobs (Muckleshoot Indian Tribe 2014b; Muckleshoot Indian Tribe and Suquamish Tribe 2017) and funding for administration and supplies for hatchery operations.

In summary, considering all effects on environmental justice from hatchery programs in the Duwamish-Green River Basin under existing conditions as described above, the hatchery programs overall have had a moderate positive effect in the environmental justice analysis area, primarily because of the substantial economic values from commercial and recreational fishing to communities of concern (especially King County and the South Puget Sound subregion), and the substantial benefits to Native American tribes of concern (especially the Muckleshoot Indian Tribe and Suquamish Tribe) from fishing for ceremonial and subsistence and commercial purposes.

3.7 Human Health

As described in Subsection 3.7, Human Health, in the PS Hatcheries DEIS [NMFS 2014a]), which is incorporated by reference, operation of hatchery facilities under current conditions may affect human health from chemicals used at hatchery facilities, procedures used in handling of those chemicals, occurrence of potentially toxic contaminants in hatchery-origin fish, and potential diseases transmitted to people from handling hatchery-origin fish. Use of chemicals may include disinfectants, therapeutics, anesthetics, pesticides and herbicides, and feed additives (Appendix K, Chemicals Used in Hatchery Operations, in the PS Hatcheries DEIS [NMFS 2014a]).

Seafood consumption by humans is generally considered to be nutritionally beneficial; however, concerns may exist when fish contain toxic contaminants that pose health risks to people. The contaminants of primary concern are those that are persistent in the environment and are known to accumulate in the tissues of fish (e.g., methylmercury, dioxins, DDTs, or PCBs) (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish, in the PS Hatcheries DEIS [NMFS 2014a]). Contaminants accumulated during hatchery rearing are expected to contribute very little to concentrations of contaminants in returning adult salmon and steelhead, because concentrations acquired only during the relatively short juvenile rearing period would be diluted as the fish grow larger to adulthood (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish, in the PS Hatcheries DEIS [NMFS 2014a]).

A number of pathogens (parasites, viruses, and bacteria) are potentially harmful to human health and can be transmitted to people if proper safety procedures are not followed (i.e., protective clothing, fish handling, and proper food preparation). Potential unsafe exposure to humans involved in hatchery operations would be from accidental skin contact and needle-stick injuries involving infected fish. Locally high concentrations of therapeutics may occur during control of disease outbreaks. In addition, based on EPA’s proposed cleanup plan for the Lower Duwamish Waterway Superfund Site (EPA 2013), a health impact assessment was conducted by Daniell et al. (2013), which found that resident fish and shellfish from the lower Duwamish River should not be consumed due to health hazards from ingesting the fish; however, the assessment also concluded that salmon within the Duwamish-Green River Basin were safe to eat because these fish are migratory and do not expend substantial time within the lower Duwamish River (Daniell et al. 2013).

As described in Subsection 3.7, Human Health, and Appendix K, Chemicals Used in Hatchery Operations, in the PS Hatcheries DEIS (NMFS 2014a), which are incorporated by reference into this EIS, effects from operation of salmon and steelhead hatchery programs in the Puget Sound area, including the Duwamish-Green River Basin, on human health are not substantial under current conditions. Similar results were found in other NEPA analyses of hatchery programs in Puget Sound river basins (Subsection 3.9, Human Health and Safety, in the Elwha FSEA [NMFS 2014b]; Subsection 3.9, Human Health and Safety, in the Dungeness Hatcheries FEA [NMFS 2016a]; and Subsection 3.9, Human Health and Safety, in the Hood Canal Hatcheries FEA [NMFS 2016b]). The effects of hatchery operations on human health under existing conditions are not substantial, primarily because hatchery operations comply with worker safety programs, rules, and regulations, the use of therapeutics is minimal and in compliance with label requirements, and personal protective equipment is used that limits the spread of pathogens.

In summary, considering all effects on human health from the hatchery programs under existing conditions, the hatchery programs overall have had a negligible negative effect on human health in the Duwamish-Green River Basin, because hatchery operations comply with worker safety programs, rules, and regulations, the use of therapeutics is minimal and in compliance with label requirements, and personal protective equipment is used that limits the spread of pathogens.

Chapter 4

4 ENVIRONMENTAL CONSEQUENCES

Chapter 4, Environmental Consequences, evaluates potential effects of the alternatives (including the Proposed Action) described in Chapter 2, Alternatives Including the Proposed Action, on the physical, biological, and human resources described in Chapter 3, Affected Environment. Chapter 3, Affected Environment, evaluates existing conditions, including the seven salmon and steelhead programs currently operating in the Duwamish-Green River Basin. Because three new hatchery programs have not been constructed (i.e., FRF hatchery programs for fall-run Chinook salmon, late winter-run steelhead, and coho salmon), these programs are not included in Chapter 3, Affected Environment; however, they are evaluated in this chapter.

As shown in Table 27, the HGMPs for the three FRF hatchery programs (fall-run Chinook salmon, late winter-run steelhead, and coho salmon) each describe two scenarios for release of hatchery-origin fish, depending on whether fish passage is provided at Howard Hanson Dam. If no fish passage is provided, then all releases would occur below Howard Hanson Dam, and fish would be released at older life stages (i.e., fall-run Chinook salmon subyearlings, late winter-run steelhead yearlings, and coho salmon yearlings). If fish passage is provided, then most of the releases for each program would occur above Howard Hanson Dam, and those fish would be released at younger life stages (i.e., subyearlings and fry) (Table 27). Hatchery-origin fish released at older and larger sizes (e.g., smolts) tend to have better smolt-to-adult survival rates than fish released at younger and smaller sizes (e.g., fry). Analyses of the two release scenarios apply to Alternative 1, Alternative 2, and Alternative 4, and for resources where differences in effects might be expected. As shown in Table 27, the total number of fish produced and released would be the same whether released above or below Howard Hanson Dam.

Table 27. Release scenarios for the FRF hatchery programs, areas of release, and maximum release levels by life stage, relative to Howard Hanson Dam for the Duwamish-Green River Basin.

Hatchery Program	Area of Release	Maximum Number to be Released by Life Stage	
		Without Fish Passage at Howard Hanson Dam	**With Fish Passage at Howard Hanson Dam**
FRF fall-run Chinook salmon	Above Howard Hanson Dam	0	500,000 fry
	Below Howard Hanson Dam	600,000 subyearlings	100,000 subyearlings
		Total 600,000	**Total 600,000**
FRF late winter-run steelhead	Above Howard Hanson Dam	0	280,000 fry
	Below Howard Hanson Dam	350,000 yearlings	70,000 yearlings
		Total 350,000	**Total 350,000**
FRF coho salmon	Above Howard Hanson Dam	0	500,000 fry
	Below Howard Hanson Dam	600,000 yearlings	100,000 yearlings
		Total 600,000	**Total 600,000**

Sources: Muckleshoot Indian Tribe 2014a, 2014c, 2014d

Under existing conditions, up to 12,443,000 juvenile salmon and steelhead are produced on an annual basis by hatcheries in the Duwamish-Green River Basin (Table 28). NMFS has defined the No-action Alternative (Alternative 1) as not making a determination under the 4(d) Rule, resulting in the hatchery programs not being exempt from ESA section 9 take prohibitions (Subsection 2.2.1, Alternative 1), but the programs are expected to continue to operate without the 4(d) Rule exemption, and it is assumed that the FRF would be constructed and operated. The co-managers could either not seek ESA coverage or seek ESA coverage using a different approach. Annual production levels under Alternative 1 would be the same as existing conditions (Table 28), except that Alternative 1 would also include production from new FRF hatchery programs as shown in Table 27, resulting in an addition of 1,550,000 fish compared to existing conditions. In comparison, the Proposed Action (Alternative 2) (Subsection 2.2.2, Alternative 2) would be exempt from ESA section 9 take prohibition by obtaining NMFS approvals under the 4(d) Rule and would have similar production levels and operations as the No-action Alternative (Alternative 1), including production from the FRF hatchery programs (Table 28).

Termination (Alternative 3) (Subsection 2.2.3, Alternative 3) would result in termination of the hatchery programs that are analyzed under Alternative 2, Proposed Action (Subsection 2.2.3, Alternative 3), and although the FRF could be built, the three FRF hatchery programs as proposed under the Proposed Action would not be approved. Thus, no salmon or steelhead as described in the 10 HGMPs would be produced at the hatchery facilities in the Duwamish-Green River Basin

(Table 28). Finally, Reduced Production (Alternative 4) (Subsection 2.2.4, Alternative 4) would result in half the number of fish produced (50 percent) annually compared to Alternative 1 and Alternative 2 (Table 28). In the analysis within Chapter 4, Environmental Consequences, all alternatives are compared to existing conditions, No Action (Alternative 1), and Proposed Action (Alternative 2).

Maximum annual hatchery release levels by species under existing conditions and under the four alternatives are shown in Table 28.

Table 28. Maximum annual hatchery releases of juvenile salmon and steelhead under existing conditions and the alternatives by species.

Species	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Fall-run Chinook salmon	4,500,000	5,100,000	5,100,000	0	2,550,000
Late winter-run steelhead	33,000	383,000	383,000	0	191,500
Summer-run steelhead	100,000	100,000	100,000	0	50,000
Coho salmon	2,810,000	3,410,000	3,410,000	0	1,705,000
Chum salmon	5,000,000	5,000,000	5,000,000	0	2,500,000
Total	**12,443,000**	**13,993,000**	**13,993,000**	**0**	**6,996,500**

Source: Muckleshoot Indian Tribe 2014a, 2014b, 2014c, 2014d; Muckleshoot Indian Tribe and Suquamish Tribe 2017; WDFW 2013, 2014a, 2014b, 2014c, 2015

The relative magnitude and direction of impacts are described using the following terms:

- Undetectable: The impact would not be detectable.
- Negligible: The impact would be at the lower levels of detection, and could be either positive or negative.
- Low: The impact would be slight, but detectable, and could be either positive or negative.
- Moderate: The impact would be readily apparent, and could be either positive or negative.
- High: The impact would be greatly positive or severely negative.

4.1 Water Quantity and Quality

Water Quantity: The analysis of water quantity addresses the effects of salmon and steelhead hatchery programs in the Duwamish-Green River Basin proposed under each alternative relative to existing conditions as described in Subsection 3.1.1, Water Quantity, and the specific allotments of water to hatchery facilities is listed in Table 6. Under existing conditions, use of surface water and groundwater by hatchery facilities is non-consumptive (Subsection 3.1.1, Water Quantity). Loss of water from existing sources may include water diversions from an adjacent stream to allow water flow through the hatchery facility or pond system and evaporation. Surface water used in hatchery facilities is then returned to its source at some location downstream of its diversion point; however, some portion of the surface water source (the bypass reach) may be dewatered (have less water between the point of diversion and discharge return to the river). Effects on existing sources include alteration of stream flow and changes in water quantity (Subsection 3.1.1, Water Quantity).

In summary, considering all potential water quantity risks, the existing salmon and steelhead hatchery programs overall have a low negative effect on water quantity in the Duwamish-Green River Basin (Table 29), primarily because water use associated with the seven hatchery programs is non-consumptive, all surface water diverted (except that lost to evaporation) is returned near the points of withdrawal after it circulates through the hatchery facilities, and the facilities comply with their state water right permits. No stream reaches are dewatered to the extent that migration and rearing of listed natural-origin fish are impaired, and there is no net loss of river or tributary flow volume.

Table 29. Comparative summary of effects on water quantity and water quality under the alternatives.

Effect Category	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Water Quantity	Low Negative	Low Negative	Low Negative	Low Negative	Low Negative
Water Quality	Negligible Negative	Negligible Negative	Negligible Negative	Negligible Positive	Negligible Negative

4.1.1 Alternative 1 (No Action) – Do Not Make a Determination under the 4(d) Rule

Under Alternative 1, the hatchery programs would operate the same as under existing conditions and produce the same number of juvenile fish. In addition, the three new FRF hatchery programs would be implemented. Up to 13,993,000 salmon and steelhead would be produced, including the 1,550,000 juvenile salmon and steelhead from the three FRF hatchery programs, relative to existing conditions, under which up to 12,443,000 salmon and steelhead would be produced (Subsection 3.2, Salmon and Steelhead) (Table 28). Two release scenarios for juvenile salmon and steelhead exist for the FRF hatchery programs as shown in Table 27.

Soos Creek Hatchery: The Soos Creek Hatchery uses surface water withdrawn from the Big Soos Creek and groundwater withdrawn from a spring (Subsection 3.1.1, Water Quantity). All water is returned to Big Soos Creek (minus evaporation) after circulating through the facilities (Subsection 3.1.1, Water Quantity). Under existing conditions, the Soos Creek Hatchery uses up to 37.6 cfs of surface water and up to 0.71 cfs of groundwater (Table 6) to support the Soos Creek fall-run Chinook salmon and Soos Creek coho salmon programs. Surface water quantity is only affected between the water intake and discharge structures. Under Alternative 1, surface water and groundwater would continue to be diverted into the hatchery to support the Soos Creek fall-run Chinook salmon and Soos Creek coho salmon programs, which is the same as under existing conditions.

Miller Creek Hatchery: Under existing conditions, the Miller Creek Hatchery uses groundwater from a well owned by the Southwest Suburban Sewer District Miller Creek water treatment plant (Table 6) to support the Soos Creek coho salmon program (Subsection 3.1.1, Water Quantity). Under Alternative 1, groundwater would continue to be diverted into the hatchery to support the Soos Creek coho salmon program, which is the same as under existing conditions.

Keta Creek Hatchery Complex: The Keta Creek Hatchery and associated Crisp Creek Ponds use surface water withdrawn from Crisp Creek and groundwater withdrawn from a spring (Subsection 3.1.1, Water Quantity). All water is returned to Crisp Creek (minus evaporation) after circulating through the facilities (Subsection 3.1.1, Water Quantity). Under existing conditions, the Keta Creek Hatchery Complex uses up to 10.6 cfs of surface water from Crisp Creek and up to 2.0 cfs of groundwater from a local spring (Table 6) to support the Keta Creek coho salmon and chum salmon programs. Surface water quantity is only affected between the water intake and discharge structures. Under Alternative 1, surface water and groundwater would continue to be diverted into the hatchery to support the Keta Creek coho salmon and chum salmon programs, which is the same as under existing conditions.

Marine Technology Center: The Marine Technology Center uses surface water from a local creek (North Creek), and all water is returned to North Creek (minus evaporation) after circulating through the facilities (Subsection 3.1.1, Water Quantity). North Creek surface water use is regulated under a water right permit deeded to the Puget Sound Skills Center through a lease from the City of Burien. Under existing conditions, the amount of water withdrawn from North Creek specific to hatchery operations to support its coho salmon program is unknown since the water right permit for this hatchery facility includes all operations associated with the Marine Technology Center (Subsection 3.1.1, Water Quantity). Under Alternative 1, surface water would continue to be diverted into the hatchery to support the Marine Technology Center coho salmon program, which is the same as under existing conditions.

Palmer Pond: Under existing conditions, Palmer Pond uses up to 15 cfs of groundwater withdrawn from a spring to support the Soos Creek fall-run Chinook salmon and Green River late winter-run steelhead programs (Subsection 3.1.1, Water Quantity, Table 6). Under Alternative 1, groundwater would continue to be diverted to support the Soos Creek fall-run Chinook salmon and Green River late winter-run steelhead programs, which is the same as under existing conditions.

Icy Creek Pond: The Icy Creek Pond uses surface water withdrawn from Icy Creek, and all water is returned to Icy Creek (minus evaporation) after circulating through the facilities (Subsection 3.1.1, Water Quantity). Under existing conditions, the Icy Creek Pond uses up to 20.0 cfs of surface water (Table 6) to support the Soos Creek fall-run Chinook salmon, Green River late winter-run steelhead, and Soos Creek summer-run steelhead programs. Surface water quantity is only affected between the water intake and discharge structures. Under Alternative 1, surface water would continue to be diverted into the hatchery to support the Soos Creek fall-run Chinook salmon, Green River late winter-run steelhead, and Soos Creek summer-run steelhead programs, which is the same as under existing conditions.

Flaming Geyser Pond: The Flaming Geyser Pond uses surface water from Cristy Creek, and all water is returned to Cristy Creek (minus evaporation) after circulating through the facilities (Subsection 3.1.1, Water Quantity). Under existing conditions, the Flaming Geyser Pond uses up to 1.5 cfs of surface water (Table 6) to support the Green River late winter-run steelhead program. Surface water quantity is only affected between the water intake and discharge structures. Under Alternative 1, surface water would continue to be diverted into the hatchery to support the Green River late winter-run steelhead program, which is the same as under existing conditions.

Fish Restoration Facility (FRF): As described in the three FRF HGMPs (Muckleshoot Indian Tribe 2014a, 2014c, 2014d), anticipated water use for the FRF hatchery programs for incubation and rearing would be up to 2 cfs of groundwater and up to 35 cfs of surface water. Water withdrawal would be non-consumptive and in compliance with a state water right permit for the FRF. All water diverted from the Green River (minus evaporation) would be returned to the river after it circulates through the hatchery facility (Subsection 3.1.1, Water Quantity). Under the two release scenarios for the FRF hatchery programs (Table 27), water use for operation of the FRF under Alternative 1 would be similar and within the permit requirements for the FRF. The minimum, mean, and maximum average daily discharge for the Green River near Palmer is 115 cfs, 683 cfs, and 7,990 cfs, respectively (USGS 2016)[20]. Although the proposed FRF could use up to 22 percent of the Green River average daily discharge at low flow conditions, this scenario is unlikely since maximum water use would most likely occur during spring months when the highest flows occur (Subsection 3.1.1, Water Quantity). The FRF does not exist under existing conditions. Consequently, a portion of Green River surface water would be diverted to support operation of the FRF hatchery programs under Alternative 1, which do not occur under existing conditions. It is expected that water use under the two release scenarios would be similar.

In summary, from the analysis described above, there would be no change in short- and long-term water use or compliance with water right permits or water rights at any of the existing hatchery facilities under Alternative 1, compared to existing conditions (Subsection 3.1.1, Water Quantity), and the water needed for salmon and steelhead production by the new FRF hatchery programs would be available through water rights that would be obtained for the FRF. This analysis assumes water rights for the FRF would be granted so there would be no effect on listed fish associated with potential use of water for the new Green River for FRF hatchery operations. Considering all existing and new hatchery facilities under Alternative 1, there would be a low negative effect on water quantity, which would be the same as under existing conditions (Table 29). This is because use of water would be non-consumptive, all surface water diverted (except that lost to evaporation) would be returned near the points of withdrawal after it circulates through the hatchery facilities, and all water use would be limited by water right permits. Surface water quantity would only be affected between the water intake and discharge structures (the bypass reach). Effects on water quantity under the two release scenarios for the FRF (Table 27) would be similar and unsubstantial. No stream reaches would be dewatered to the extent that migration and rearing of listed natural-origin fish would be impaired and there would be no net loss of river or tributary flow volume.

4.1.2 Alternative 2 (Proposed Action) – Make a Determination that the Submitted HGMPs Meet the Requirements of the 4(d) Rule

Under Alternative 2, the hatchery programs would operate as proposed in the submitted HGMPs and the FRF would be constructed (Subsection 2.2.2, Alternative 2). Up to 13,993,000 salmon and steelhead would be produced, including 1,550,000 juvenile salmon and steelhead from the three new FRF hatchery programs, relative to existing conditions under which up to 12,443,000 salmon and

[20] Summary of USGS discharge record for the Green River near Palmer, streamflow monitoring station #121067000 for water years 2006 to 2015 (10 most recent water years).

steelhead would be produced (Subsection 3.2, Salmon and Steelhead) (Table 28). The number of fish produced would be the same as under Alternative 1 (Table 28). There would be no change in short- and long-term water use or compliance with water right permits or water rights at any of the hatchery facilities under Alternative 2, compared to existing conditions and Alternative 1. Under the two release scenarios for FRF hatchery programs, as shown in Table 27, water use for operation of the FRF would remain within its water right permit requirements, which is the same as Alternative 1, but which does not occur under existing conditions because the FRF has not yet been constructed.

In summary, under Alternative 2, there would be a low negative effect on water quantity, which would be the same as under existing conditions and Alternative 1 (Table 29), because water use would be non-consumptive, all water diverted (except that lost to evaporation) would be returned near the points of withdrawal after it circulates through the hatchery facilities, and all water use would be limited by water right permits. Surface water quantity would only be affected between the water intake and discharge structures (the bypass reach). Effects on water quantity under the two release scenarios for the FRF (Table 27) would be similar and unsubstantial. No stream reaches would be dewatered to the extent that migration and rearing of listed natural-origin fish would be impaired and there would be no net loss of river or tributary flow volume.

4.1.3 Alternative 3 (Termination) – Make a Determination that the Submitted HGMPs Do Not Meet the Requirements of the 4(d) Rule

Under Alternative 3, the hatchery programs would be terminated (Subsection 2.2.3, Alternative 3), and no hatchery-origin salmon or steelhead associated with the proposed HGMPs would be produced relative to existing conditions (Table 28). All of the hatchery facilities that support the proposed hatchery programs would continue to operate. Although the hatchery facilities would not produce up to 13,993,000 salmon and steelhead as proposed in the HGMPs, because the facilities would continue to exercise their water rights, there would be no change in short- and long-term water use or compliance with water right permits or water rights at any of the hatchery facilities under Alternative 3, compared to existing conditions, Alternative 1 and Alternative 2. Water use for operation of the FRF would be within its water right permit requirements, which would be the same as under Alternative 1 and Alternative 2, but which does not occur under existing conditions.

In summary, under Alternative 3 there would be a low negative effect on water quantity, which would be the same as under existing conditions, Alternative 1, and Alternative 2 (Table 29), because water use would be limited by water right permits.

4.1.4 Alternative 4 (Reduced Production) – Make a Determination that the Revised HGMPs with Reduced Production Levels Meet the Requirements of the 4(d) Rule

Under Alternative 4, production from the existing and new hatchery programs would be reduced 50 percent (Subsection 2.2.4, Alternative 4) compared to Alternative 1 and Alternative 2, but the facilities would continue to exercise their water rights. As described in the FRF HGMPs, water use for operation of the FRF under the two release scenarios would be within its water right permit requirements. Under Alternative 4, water use for hatchery production would be for up to 5,446,500 fewer salmon and steelhead than under existing conditions, and up to 6,996,500 fewer salmon and steelhead than under Alternative 1 and Alternative 2. However, because the facilities would continue to exercise their water rights, there would be no change in short- and long-term water use or compliance with water right permits or water rights at any of the hatchery facilities under Alternative 4, compared to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 4 there would be a low negative effect on water quantity, which would be the same as under existing conditions, Alternative 1, Alternative 2, and Alternative 3 (Table 29), because water use would be non-consumptive, all water diverted (except that lost to evaporation) would be returned near the points of withdrawal after it circulates through the hatchery facilities, and all water use would be limited by water right permits. Surface water quantity would only be affected between the water intake and discharge structures (the bypass reach). Effects on water quantity under the two release scenarios for the FRF (Table 27) would be similar and unsubstantial. No stream reaches would be dewatered to the extent that migration and rearing of listed natural-origin fish would be impaired and there would be no net loss of river or tributary flow volume.

Water Quality: As described in Subsection 3.1.2, Water Quality, this EIS incorporates by reference the information and results from water quality analyses in Subsection 3.6.1, Water Quality, and Appendix J, Water Quality and Regulatory Compliance for Puget Sound Hatchery Facilities, in the PS Hatcheries DEIS (NMFS 2014a). Although hatchery facilities (including hatcheries, rearing ponds, acclimation ponds, and net pens), in general, are not identified as sources of water quality impairment to streams based on hatchery facility effluent releases, the effluent released from hatchery facilities contributes to the total pollutant load of receiving and downstream waters.

Periodic effluent permit limit exceedances of suspended and settleable solids also result in higher contributions to total pollutant loads, with the most common exceedances occurring for suspended solids that are typically one-time occurrences caused by high water flow events that flush influent sediments through the hatchery facility system (Subsection 3.6.1.2, Applicable Hatchery Facility

Regulations and Compliance, in the PS Hatcheries DEIS [NMFS 2014a]). Salmon and steelhead carcasses placed into streams after being spawned at hatchery facilities to increase beneficial marine-derived nutrients (nitrogen and phosphorus) (Subsection 3.2.3.8, Nutrient Cycling), may also effect water quality. Overall, based on the information in the PS Hatcheries DEIS (NMFS 2014a), and Subsection 3.1.2, Water Quality, the effects on water quality from salmon and steelhead hatchery programs in the Duwamish-Green River Basin are unsubstantial under existing conditions, primarily because hatchery operations limit their pollutant discharges in accordance with their NPDES permits and do not contribute substantially to water quality impairments in the basin.

In summary, considering all potential water quality risks, the existing salmon and steelhead hatchery programs overall have a negligible negative effect on water quality in the Duwamish-Green River Basin (Table 29), primarily because hatchery operations limit their pollutant discharges in accordance with their NPDES permits and do not contribute substantially to water quality impairments in the basin.

Alternative 1: Under Alternative 1, the effects from hatchery operations on water quality associated with the seven existing hatchery programs would be the same as under existing conditions (Subsection 3.1.2, Water Quality), which would release up to 12,443,000 salmon and steelhead annually (Table 28). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from three new FRF hatchery programs (Table 28). As shown in Table 7, the 303(d) list status of water bodies into which existing hatchery facilities discharge effluents are identified, along with impaired parameters. The FRF facilities at RM 60 on the mainstem of the river would discharge effluent into the river that has dissolved oxygen and temperature impairments. The three new hatchery programs would also release effluents, and the total amount of effluent from the hatchery programs would increase compared to existing conditions. Water quality parameters that could be negatively affected by hatchery operations would be the same as under existing conditions, and hatchery operations would limit their pollutant discharges in accordance with their NPDES permits and would not be expected to contribute substantially to water quality impairments in the basin.

In summary, under Alternative 1, considering all potential water quality risks, the salmon and steelhead hatchery programs overall would have a negligible negative effect on water quality in the Duwamish-Green River Basin (Table 29), which would be the same as under existing conditions, primarily because hatchery operations would not be expected to contribute substantially to water quality impairments in the basin.

Alternative 2: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would total 13,993,000 juveniles, which would be same as under Alternative 1 (Table 28). Water quality effects would be the same as under Alternative 1, primarily because all hatchery programs would limit their pollutant discharges in accordance with all NPDES permits and would not be expected to contribute substantially to water quality impairments in the basin.

In summary, under Alternative 2, considering all potential water quality risks, the salmon and steelhead hatchery programs overall would have a negligible negative effect on water quality in the Duwamish-Green River Basin (Table 29), primarily because hatchery operations would not be expected to contribute substantially to water quality impairments in the basin, which would be the same as under existing conditions and Alternative 1.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and would not release 12,443,000 salmon and steelhead as under existing conditions, and the additional 1,550,000 salmon and steelhead juveniles produced by the new FRF hatchery programs under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all water quality effects associated with the ongoing and proposed new hatchery programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 3, considering all potential water quality risks, the elimination of the salmon and steelhead programs overall would have a negligible positive effect on water quality in the Duwamish-Green River Basin (Table 29), because all water quality effects from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2.

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release 5,446,500 fewer hatchery-origin salmon and steelhead from ongoing and proposed new FRF hatchery programs than under existing conditions, and 6,996,500 fewer fish than under Alternative 1 and Alternative 2 (Table 28). Although fewer fish would be produced under Alternative 4 compared to Alternative 1 and Alternative 2, water quality effects would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because all hatchery programs would be comply with their NPDES permits and would not be expected to contribute substantially to water quality impairments in the basin.

In summary, under Alternative 4, considering all potential water quality effects, the salmon and steelhead hatchery programs overall would have a negligible negative effect on water quality in the Duwamish-Green River Basin (Table 29), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because the hatchery programs would limit their pollutant discharges in accordance with their NPDES permits and would not be expected to contribute substantially to water quality impairments in the basin. In comparison to Alternative 3 (negligible positive), water quality effects under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for water quality effects.

4.2 Salmon and Steelhead

The salmon and steelhead analyses address effects of salmon and steelhead hatchery programs proposed under each alternative on existing conditions described in Subsection 3.2, Salmon and Steelhead. The analysis focuses on effects of the hatchery programs on natural-origin salmon and steelhead that are self-sustaining in the natural environment and are dependent on aquatic habitat for migration, spawning, rearing, and food. Pink salmon are included in the evaluation even though there are no existing or planned hatchery programs for pink salmon in the project area, because they can be affected by hatchery programs in the project area. Since only a small number of riverine sockeye salmon and no anadromous sockeye salmon occur in the project area (Gustafson et al. 1997; Gustafson and Winans), sockeye salmon are not evaluated in this EIS.

This subsection describes effects on salmon and steelhead associated with the alternatives for the categories described in Subsection 3.2.2.1, General Effects of Puget Sound Salmon and Steelhead Hatchery Programs, as listed below:

- Genetics
- Competition and Predation
- Facility Operations
- Masking
- Incidental Fishing
- Disease
- Population Viability Benefits
- Nutrient Cycling

In addition to hatchery-related effects, decreases in the quality and extent of salmon and steelhead habitat, harvest, the presence of dams and diversions, and changes in ocean conditions and climate have all contributed to impacting salmon and steelhead in the analysis area (Subsection 3.2.1, General

Factors that Affect the Presence and Abundance of Salmon and Steelhead). Analysis of fish resources in Subsection 4.2, Salmon and Steelhead, is focused on the effects under the alternatives associated with salmon and steelhead hatchery production, which is one of the general factors affecting salmon and steelhead in the analysis area (Subsection 3.2.1, General Factors that Affect the Presence and Abundance of Salmon and Steelhead). The effects on salmon and steelhead from other general factors (e.g., habitat, climate change) are described in Chapter 5, Cumulative Effects.

As described in Subsection 3.2.3, Effects of Current Duwamish-Green River Basin Hatchery Programs on Salmon and Steelhead, monitoring and evaluation activities occur under existing conditions overall have a negligible negative effect. Such activities are addressed under separate approvals under the ESA. Monitoring and evaluation would be required by NMFS as a condition of its approval under the 4(d) Rule (Subsection 1.5.3, NMFS's Determination as to Compliance with the 4(d) Rule). Monitoring and evaluation under the HGMPs would address performance of the hatchery programs by helping to reduce technical uncertainties and informing adaptive management of objectives. Subsection 1.2, Description of the Proposed Action, identifies monitoring activities. These activities would include, but not be limited to, obtaining information on smolt-to-adult survival, fishery contribution, natural-origin and hatchery-origin spawning abundance, juvenile out-migrant abundance and diversity, genetics (DNA) and gene flow, and juvenile and adult fish health when the fish are in the hatchery. Monitoring of the VSP (McElhany et al. 2000) status of listed populations would be an important component of recovery plan and HGMP implementation. The monitoring activities and their effects (negligible negative effect) would be the same under existing conditions and all of the action alternatives except Alternative 3, under which the salmon and steelhead hatchery programs would be terminated. Under Alternative 3, monitoring related to the terminated hatchery programs and population viability status monitoring implemented under existing conditions and as part of HGMP actions would not occur. Thus, compared to existing conditions and the other action alternatives, monitoring under Alternative 3 would have a negligible positive effect, although information on population viability status would be reduced or lost.

4.2.1 Genetics

Genetic effects on natural-origin salmon and steelhead from hatchery programs include within-population diversity effects (associated with the source or type of broodstock used [e.g., local or non-local]), outbreeding effects (gene flow from hatchery-origin fish to natural-origin fish), and hatchery-influenced selection effects (sometimes called domestication, whereby hatchery-origin fish are propagated over multiple generations, thereby adapting to the hatchery environment) as described in Subsection 3.2.3.1, Genetics.

Of the 10 existing and proposed salmon and steelhead hatchery programs in the Duwamish-Green River Basin, 8 would be operated as integrated programs, and 2 (Soos Creek summer-run steelhead and Marine Technology Center coho salmon programs) would be operated as isolated programs (Table 3). In integrated hatchery programs, local natural-origin adults are incorporated into hatchery broodstock with the intent to minimize the genetic differences between hatchery-origin fish and the natural-origin population from which they are derived (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). Fish from integrated programs may be used for harvest and/or conservation purposes. In contrast, fish produced from isolated hatchery programs (sometimes also called segregated programs) are genetically different from the local natural-origin fish, are reproductively isolated from the natural-origin population, and natural-origin fish are not incorporated into hatchery broodstocks. These programs do not contribute to conservation or recovery; instead, the programs are designed to contribute to harvest in their respective river basins while minimizing negative impacts on natural-origin populations. There are no genetic effects on natural-origin pink salmon because there are no hatchery programs for pink salmon in the project area.

4.2.1.1 Chinook Salmon

There is one existing Chinook salmon hatchery program in the Duwamish-Green River Basin (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). NMFS views the natural-origin fall-run Chinook salmon population in the Green River Basin as a Tier 2 Chinook salmon population for consultations and ESU recovery planning purposes (Subsection 1.7.12, Recovery Plans for Puget Sound Salmon and Steelhead). The existing Soos Creek fall-run Chinook salmon program is an integrated program, and fish released from this program are intended to be genetically similar to the natural-origin fall-run Chinook salmon that spawn naturally in the Green River and its tributaries. Although the broodstock used are of local origin and the pNOB is relatively low (12 percent), the pHOS averages 0.66 of the total escapement, the PNI is 0.19, and the number of fish released is substantial (4,500,000 juveniles) (Subsection 3.2.3.1, Genetics). To some extent, these conditions may have a negative effect on the productivity and fitness of the natural-origin fall-run Chinook salmon population.

In summary, under existing conditions, the integrated program overall has a moderate negative genetic effect (Table 30) on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (a Tier 2 Chinook salmon population under NMFS' PRA), primarily because although broodstock are of local origin, the pNOB and PNI are relatively low, and the program size is relatively large (4,500,000 juveniles).

Table 30. Comparative summary of genetic effects on natural-origin salmon and steelhead under the alternatives.

Natural-origin Species	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Fall-run Chinook Salmon	Moderate negative	Moderate negative	Moderate negative	Moderate positive	Low negative
Steelhead	High negative	High negative	High negative	High positive	High negative
Coho Salmon	Low negative	Moderate negative	Moderate negative	Moderate positive	Low negative
Chum Salmon	Low negative	Low negative	Low negative	Low positive	Low negative

Alternative 1: Under Alternative 1, the Soos Creek fall-run Chinook salmon hatchery program would continue to operate as an integrated program, and fish from this program would be genetically similar to natural-origin fall-run Chinook salmon in the Green River. As described in Subsection 3.2.3.1, Genetics, the broodstock would be of local origin, the pNOB would be relatively low, the pHOS each year would continue to average 66 percent of the total escapement, and the program size would continue to be relatively large. Also under Alternative 1, in contrast to existing conditions, an additional 600,000 fall-run Chinook salmon juveniles would be produced from the new integrated FRF fall-run Chinook salmon program, which would increase the total number of juveniles released by 13 percent to 5,100,000 compared to 4,500,000 under existing conditions (Table 28). The hatchery program would commence using hatchery-origin adults returning to the Soos Creek Hatchery.

Considering overall genetic effects from the two integrated fall-run Chinook salmon programs to natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin, the increase in Chinook salmon hatchery production from the new FRF hatchery program by 600,000 juveniles compared to existing conditions (Table 28), would marginally increase the potential for genetic changes resulting from effects such as hatchery-influenced selection. The pNOB, pHOS, and PNI would be expected to be similar to existing conditions. As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery program, associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as subyearlings below the dam with no passage, or 17 percent released as subyearlings below the dam and 83 percent released as fry above the dam with passage). It is expected that the genetic effects on the natural-origin fall-run Chinook salmon population would be similar (i.e., as estimated by the pNOB, pHOS, and PNI) for each of the release scenarios for the new FRF hatchery program (Table 27). To some extent, these conditions may have a negative effect on the productivity and fitness of the natural-origin fall-run Chinook salmon population.

In summary, under Alternative 1, although the increased production associated with the new FRF fall-run Chinook salmon program would marginally increase genetic effects (hatchery-influenced selection) on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin, the programs overall would have a moderate negative genetic effect (Table 30), which would be the same as under existing conditions, primarily because the pNOB and PNI would be relatively low, and the program sizes would be relatively large (5,100,000 fall-run Chinook salmon juveniles).

Alternative 2: Under Alternative 2, the Soos Creek and new FRF fall-run Chinook salmon hatchery programs would operate as under Alternative 1. Releases of fall-run Chinook salmon from the two hatchery programs would total 5,100,000 Chinook salmon juveniles, which is the same as under Alternative 1 (Table 28). Genetic effects on the natural-origin fall-run Chinook salmon population associated with each of two release scenarios for the new FRF fall-run Chinook program (Table 27) would be the same, as under Alternative 1.

In summary, under Alternative 2, the fall-run Chinook salmon programs overall would have a moderate negative genetic effect on fall-run Chinook salmon in the Duwamish-Green River Basin, which would be the same as under existing conditions and Alternative 1 (Table 30), primarily because the pNOB and PNI would be relatively low, and the numbers of fish released would be relatively large (5,100,000 fall-run Chinook salmon juveniles).

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and the Soos Creek fall-run Chinook hatchery program would not release 4,500,000 juvenile fall-run Chinook salmon as under existing conditions, and the additional 600,000 juveniles produced by the new FRF fall-run Chinook salmon program under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all genetic effects (within-population genetic diversity, outbreeding, and hatchery-influenced selection effects) on natural-origin fall-run Chinook salmon associated with the ongoing and proposed new programs would be discontinued compared to existing conditions, Alternative 1, and Alternative 2, and theoretically may diminish over time as traits in the combined population trend back toward natural-origin characteristics, though as stated in Subsection 3.2.3.1, Genetics, this theory is untested. No natural-origin fall-run Chinook salmon would be collected for hatchery broodstock, and over time, once all of the fall-run Chinook salmon from previous hatchery releases in the river basin have returned, there would be no hatchery-origin fall-run

Chinook salmon returning to or spawning in the river basin that were produced by the hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, the elimination of the two fall-run Chinook salmon programs overall would have a moderate positive genetic effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 30), because all genetic effects on natural-origin fall-run Chinook salmon from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, Alternative 2 (which would all have a moderate negative genetic effect).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2. The Soos Creek fall-run Chinook salmon hatchery program would release 1,950,000 fewer fish than under existing conditions, Alternative 1, and Alternative 2, and 300,000 fewer fish would be released from the new FRF integrated fall-run Chinook salmon hatchery program than under Alternative 1 and Alternative 2 (Table 28). The total number of hatchery-origin fall-run Chinook salmon released under Alternative 4 would be 2,550,000 juveniles, compared to 4,500,000 juveniles under existing conditions, 5,100,000 juveniles under Alternative 1 and Alternative 2, and no releases from the programs under Alternative 3 (Table 28). Under Alternative 4, the total number of broodstock needed would be lower, and assuming the same number of natural-origin broodstock would be used, the percentage of natural-origin fish used as broodstock would increase, compared to existing conditions, Alternative 1, and Alternative 2. These changes would be expected to also increase PNI (higher than 0.19, but likely less than 0.5). The combined program sizes however, would continue to be relatively large. To some extent, these conditions may lead to improved productivity and fitness of the natural-origin fall-run Chinook salmon population, relative to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 4, the fall-run Chinook salmon programs overall would have a low negative genetic effect (from outbreeding [gene flow] and hatchery-influenced selection) on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin, which would be less than under existing conditions, Alternative 1, and Alternative 2 (Table 30), primarily because the numbers of fish released would be considerably less but substantial (Table 28), the broodstock used for the programs would be of local origin, and the pNOB and PNI would likely be higher. As under Alternative 1 and Alternative 2, under Alternative 4 the genetic effects on natural-origin fall-run Chinook salmon associated with each of the two release scenarios for the new FRF fall-run Chinook salmon program would be the same. The negative genetic effect under Alternative 4 (low negative) would be greater than the genetic effect under Alternative 3 (moderate positive) (Table 30), under which the programs would be terminated, and all genetic effects on natural-origin fall-run Chinook salmon from hatchery-origin fall-run Chinook salmon (within-population genetic diversity, outbreeding, and hatchery-influenced selection effects) produced by the ongoing and proposed new FRF fall-run Chinook salmon programs in the Duwamish-Green River Basin would be eliminated.

4.2.1.2 Steelhead

There are two existing steelhead hatchery programs in the Duwamish-Green River Basin (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). The existing Green River late winter-run steelhead hatchery program is an integrated program, and the fish released from this program are intended to be genetically similar to natural-origin steelhead that spawn in the Green River watershed and its tributaries. Under existing conditions, the program uses broodstock of local origin, the program is small in size (33,000 yearlings are released), and the effect of hatchery-influenced selection has likely been minimal. These conditions help increase the potential for within-population genetic diversity to be maintained, decrease risks of outbreeding depression from hatchery-origin fish, and decrease the potential for hatchery-influenced selection.

The existing Soos Creek early summer-run steelhead hatchery program is an isolated program, and poses no genetic risks to natural-origin summer-run steelhead, because indigenous natural-origin summer-run steelhead do not currently exist in the Duwamish-Green River Basin (Subsection 3.2.3.1, Genetics). However, outbreeding effects (gene flow) from the early summer-run steelhead program into the natural-origin winter-run steelhead population occur (Subsection 3.2.3.1, Genetics). Based on genetic data (PEHC, Warheit Method) the average gene flow from early summer-run steelhead into the natural-origin Green River winter-run steelhead population from past practices is 1 percent, and 2 percent from more recent projected practices. Using a different method (DGF, referred to as the Scott-Gill Method) (Subsection 3.2.3.1, Genetics), the average gene flow into natural-origin winter-run steelhead is 2 percent for past and projected practices (but with a range of 1.3 to 3.4 percent for projected practices). The effects on fitness of the natural-origin winter-run steelhead from this low level of gene flow is likely to be substantial, because the early summer-run steelhead program was developed using broodstock originating in the Lower Columbia River Steelhead DPS (not in the local Puget Sound Steelhead DPS), and such gene flow between the two DPSs would not be expected under natural conditions. In addition, the early summer-run steelhead produced by the program have been subjected to considerable hatchery-influenced selection. A total of 100,000 summer-run steelhead yearlings are released by the Soos Creek early summer-run steelhead program.

In summary, the existing steelhead hatchery programs overall have a high negative genetic effect (the highest effect category used in this analysis) on natural-origin winter-run steelhead in the Duwamish-Green River Basin (Table 30) because of the genetic effect of outbreeding associated with low levels of gene flow from the highly domesticated isolated Soos Creek early summer-run steelhead program that was developed using broodstock originating from ouside the local DPS (Subsection 3.2.3.1, Genetics).

Alternative 1: Under Alternative 1, the integrated Green River late winter-run steelhead and isolated Soos Creek early summer-run steelhead programs would continue to operate as under existing conditions, and genetic effects from those two programs on natural-origin winter-run steelhead would be the same as under existing conditions (e.g., gene flow from the early summer-run steelhead program into the natural-origin winter-run steelhead population would be up to 2 percent). Also under Alternative 1, in contrast to existing conditions, an additional 350,000 late winter-run steelhead juveniles would be released from the new FRF integrated late winter-run steelhead program, which would use locally-returning fish as broodstock. This new program would increase the total number of hatchery-origin steelhead juveniles released under Alternative 1 by 263 percent to 483,000 fish, compared to 133,000 under existing conditions (Table 28). For at least the early stages of the program, broodstock would probably be obtained from returns of hatchery-origin fish from the Green River late winter-run steelhead hatchery program (Muckleshoot Indian Tribe 2014a).

Although most genetic effects from the new FRF late winter-run steelhead program would be expected to be similar to the existing late winter-run steelhead hatchery program, the release of an additional 350,000 hatchery-origin winter-run steelhead would increase the potential for reduced genetic diversity, and increased hatchery-influenced selection and gene flow. The program may inadvertently reduce the effective breeding size of the Green River natural-origin population, potentially reducing genetic diversity. This risk would be managed by limiting the proportion of natural-origin broodstock that would be removed annually to 20 percent or less of the natural-origin population (Muckleshoot Indian Tribe 2014a). In addition, a minimum of 50 percent of the broodstock each year would be of natural-origin, with a goal of using 100 percent natural-origin fish. Fish used as broodstock would be representative of the run-timing, sex ratio, and age structure of natural-origin winter-run steelhead returning to the Duwamish-Green River Basin. Overall, these conditions would help increase the potential for within-population genetic diversity to be maintained, decrease risks of outbreeding depression from hatchery-origin fish, and decrease the potential for hatchery-influenced selection. As shown in Table 27, there would be two different scenarios for releases of hatchery-origin late winter-run steelhead from the new FRF late winter-run steelhead program, that would be associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as yearlings below the dam with no passage, or 20 percent released as yearlings below the dam and 80 percent released as fry above the dam with passage). It is expected that genetic effects (gene flow) associated with the two release scenarios (Table 27) from this new FRF hatchery program on the natural-origin winter-run steelhead population would be similar.

In summary, under Alternative 1, although the increased production associated with the new FRF late winter-run steelhead program would increase genetic effects on natural-origin winter-run steelhead in the Duwamish-Green River Basin, the three steelhead hatchery programs overall would have a high (the highest category of effect) negative genetic effect, which would be the same as under existing conditions (Table 30), primarily because of the genetic effects of outbreeding associated with low levels of gene flow from releases from the highly domesticated isolated Soos Creek early summer-run steelhead program that would use broodstock originating from outside the Puget Sound Steelhead DPS. Under Alternative 1, genetic effects of hatchery-influenced selection associated with the substantial number of fish released from the new FRF late winter-run steelhead hatchery program would probably increase and contribute to the already high negative genetic effect on natural-origin winter-run steelhead in the Duwamish-Green River Basin.

Alternative 2: Under Alternative 2, the Soos Creek early summer-run, Green River late winter-run, and new FRF late winter-run steelhead programs would operate as under Alternative 1. Releases of steelhead from the three hatchery programs would total 483,000 juveniles (Table 28), and genetic effects from those releases would be the same as under Alternative 1 (e.g., gene flow from the early summer-run steelhead program into the natural-origin winter-run steelhead population would be 2 percent or less). Under Alternative 2, as under Alternative 1, the additional 350,000 late winter-run steelhead juveniles that would be released from the new FRF integrated late winter-run steelhead program (Table 28) would increase genetic impact on natural-origin steelhead compared to existing conditions, primarily from the increased potential for reduced genetic diversity and increased hatchery-influenced selection and gene flow. However, as under Alternative 1, conditions applied to use of local broodstock for this new FRF program would increase the potential for within-population genetic diversity to be maintained, decrease risks of outbreeding depression from hatchery-origin fish, and decrease the potential for hatchery-influenced selection. Genetic effects (gene flow) on the natural-origin steelhead population associated with each of the two release scenarios for the new FRF late winter-run steelhead program (Table 27) would be the same, as under Alternative 1.

In summary, under Alternative 2, the three steelhead hatchery programs overall would have a high (the highest category of effect) negative genetic effect on natural-origin steelhead in the Duwamish-Green River Basin, which would be the same as under existing conditions and Alternative 1 (Table 30), primarily because of the genetic effects of outbreeding associated with low levels of gene flow due to releases from the highly domesticated isolated Soos Creek early summer-run steelhead program that would use broodstock originating from outside the Puget Sound Steelhead DPS. Under Alternative 2, as under Alternative 1, increased production associated with the new FRF late winter-run steelhead program would increase the genetic effects compared to existing conditions, which would contribute to the already high negative genetic effects (gene flow).

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and the Soos Creek early summer-run and Green River late winter-run steelhead hatchery programs would not release 133,000 steelhead yearlings as under existing conditions and the additional 350,000 juvenile steelhead produced by the new FRF late winter-run steelhead program under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all genetic effects (within-population genetic diversity, outbreeding [gene flow], and hatchery-influenced selection) on natural-origin steelhead from hatchery-origin steelhead associated with the ongoing and proposed new FRF programs would be discontinued relative to existing conditions, Alternative 1, and Alternative 2, and theoretically may diminish over time as traits in the combined population trend back toward natural-origin characteristics, though as stated above in Subsection 3.2.3.1, Genetics, this theory is untested. No natural-origin steelhead would be collected for hatchery broodstock, and over time, once all of the steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin steelhead returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, the elimination of all the steelhead programs overall would have a high positive genetic effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 30) because all genetic effects (within-population genetic diversity, outbreeding, and hatchery-influenced selection effects) on natural-origin steelhead from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which would all have a high negative genetic effect).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 2, and the isolated Soos Creek early summer-run and integrated Green River late winter-run steelhead programs would release 66,500 fewer fish (including 50,000 fewer Soos Creek early summer-run fish and 16,500 fewer Green River late winter-run fish) than under existing conditions, Alternative 1, and Alternative 2, and 175,000 more fish would be released from the new FRF late winter-run steelhead hatchery program than under existing conditions, but 175,000 fewer fish from the program would be released than under Alternative 1 and Alternative 2 (Table 28). The total number of hatchery-origin steelhead released under Alternative 4 would be 241,500 juveniles, compared to 133,000 juveniles under existing conditions, 483,000 juveniles under Alternative 1 and Alternative 2, and no releases from the programs under Alternative 3 (Table 28).

Under Alternative 4, overall genetic effects (reduced genetic diversity, and increased gene flow and hatchery-influenced selection) from the steelhead hatchery programs would be expected to be less than under Alternative 1 and Alternative 2 because, although the broodstocks used for the three programs would be the same and 50 percent fewer fish would be released, release numbers would still be substantial (Table 28). As under existing conditions, Alternative 1, and Alternative 2, highly domesticated Soos Creek early summer-run steelhead from broodstock originating from outside the Puget Sound Steelhead DPS would be released. Because of the reduced release level, gene flow from the early summer-run steelhead program into the natural-origin winter-run steelhead population would most likely be less than 2 percent. Under Alternative 4, as under Alternative 1 and Alternative 2, the additional late winter-run steelhead juveniles that would be released from the new FRF integrated late winter-run steelhead program (Table 28) would increase genetic effects (e.g., reduced genetic diversity and increased hatchery-influenced selection) on natural-origin steelhead compared to existing conditions, but to a lesser extent than under Alternative 1 and Alternative 2. As under Alternative 1 and Alternative 2, under Alternative 4 the genetic effects (gene flow) on natural-origin winter-run steelhead associated with each of the two release scenarios for the FRF steelhead program would be the same.

In summary, under Alternative 4, the three steelhead programs overall would have a high (the highest category of effect) negative genetic effect on natural-origin steelhead in the Duwamish-Green River Basin, which would be the same as under existing conditions, Alternative 1, and Alternative 2 (Table 30), primarily because of the genetic effects on outbreeding associated with potentially low levels of gene flow from releases from the highly domesticated isolated Soos Creek early summer-run steelhead program that would use broodstock originating from outside the Puget Sound Steelhead DPS. Although the numbers of steelhead released from each of the three hatchery programs would be reduced, releases would still be substantial (Table 28). The negative genetic effect under Alternative 4 (high negative) would be greater than the genetic effect under Alternative 3 (high positive) (Table 30), under which the hatchery programs would be terminated and all genetic effects (within-population genetic diversity, outbreeding, and hatchery-influenced selection) on natural-origin steelhead from hatchery-origin steelhead associated with the ongoing and proposed new steelhead programs in the river basin would be eliminated.

4.2.1.3 Coho Salmon

There are three existing coho salmon hatchery programs in the Duwamish-Green River Basin (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). Two of these programs (Soos Creek and Keta Creek coho salmon programs) are operated as integrated programs, and the fish released from these programs are intended to be genetically similar to natural-origin coho salmon that spawn in the Green River watershed and its tributaries. Although hatchery-influenced selection has likely occurred and the size of the two programs is relatively large (totaling 2,80,000 million juveniles), broodstock used are of local origin and the PNI for the Soos Creek coho salmon program is relatively high at 0.68, which would likely help maintain fitness and productivity of the natural-origin population (Subsection 3.2.3.1, Genetics). The Marine Technology Center isolated coho salmon program uses broodstock derived from Soos Creek that return to the Marine Technology Center facility. Genetic effects from this program are unlikely because there are no natural-origin coho salmon populations at or adjacent to the hatchery facility into which the relatively small number of returning adults could stray (Subsection 3.2.3.1, Genetics).

In summary, the existing three coho salmon hatchery programs overall have a low negative genetic effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 30), primarily because, although there is likely a genetic effect of hatchery-influenced selection from the two integrated programs and the size of those programs is relatively large (totaling 2,800,000 juveniles), broodstock are of local origin, and the PNI for the Soos Creek coho salmon program is relatively high (Subsection 3.2.3.1, Genetics).

Alternative 1: Under Alternative 1, the two integrated hatchery programs and the isolated coho salmon hatchery programs would continue to operate as under existing conditions, and genetic effects of hatchery-influenced selection from those three programs on natural-origin coho salmon, and PNI for the integrated Soos Creek coho salmon program, would be the same as under existing conditions. Also under Alternative 1, in contrast to existing conditions, an additional 600,000 coho salmon juveniles would be released from the new FRF integrated coho salmon program that also would be based on local broodstock. This would increase the total number of coho salmon juveniles released under

Alternative 1 by 21 percent to 3,410,000 fish, compared to 2,810,000 under existing conditions (Table 28).

Although most genetic effects from the new FRF coho salmon program would likely be similar to the existing two integrated coho salmon hatchery programs, the release of an additional 600,000 hatchery-origin coho salmon would increase the potential for genetic effects, such as reduced genetic diversity, by inadvertently reducing the effective breeding size and increasing hatchery-influenced selection. As shown in Table 27, there would be two different scenarios for releases of hatchery-origin coho salmon from the new FRF hatchery program that would be associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as yearlings below the dam with no passage, or 17 percent released as yearlings below the dam and 83 percent released as fry above the dam with passage). It is expected that genetic effects (reduced genetic diversity and increased hatchery-influenced selection) associated with the two release scenarios (Table 27) from this new FRF coho salmon program on the natural-origin coho salmon population would be similar.

In summary, under Alternative 1, the four coho salmon hatchery programs overall would have a moderate negative genetic effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 30), which would be higher than under existing conditions (low negative), primarily because of the new FRF coho salmon program and its additional potential for the genetic effects of reduced genetic diversity and increased hatchery-influenced selection stemming from the relatively large number of releases from all four programs (totaling 3,410,000 juveniles).

Alternative 2: Under Alternative 2, the Soos Creek, Keta Creek, Marine Technology Center, and new FRF coho salmon hatchery programs would operate as under Alternative 1. Releases of coho salmon from the four hatchery programs would total 3,410,000 juveniles (Table 28), and genetic effects of reduced genetic diversity and increased hatchery-influenced selection from those releases would be the same as under Alternative 1. Under Alternative 2, as under Alternative 1, the additional 600,000 coho salmon juveniles that would be released from the new FRF integrated coho salmon program (Table 28), would increase genetic impacts on natural-origin coho salmon compared to existing conditions, primarily because of genetic effects of reduced genetic diversity and increased hatchery-influenced selection. Genetic effects (reduced genetic diversity and increased hatchery-influenced selection) on the natural-origin coho salmon population associated with each of the two release scenarios for the new FRF coho salmon program (Table 27) would be the same, as under Alternative 1.

In summary, under Alternative 2, the four coho salmon programs overall would have a moderate negative genetic effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 30), which would be the same as under Alternative 1, primarily because fish from the existing and new coho salmon programs will have undergone some extent of hatchery-influenced selection, the program may inadvertently reduce the effective breeding size and genetic diversity, and the total size of the four programs would be relatively large (3,410,000 juveniles). However, broodstock used would continue to be of local origin. Genetic effects under Alternative 2 (moderate negative) would be greater than under existing conditions (low negative) (Table 30), because of the genetic effect of reduced genetic diversity and increased hatchery-influenced selection associated with the new FRF coho salmon program, that does not occur under existing conditions.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and the Soos Creek, Keta Creek, and Marine Technology Center coho salmon hatchery programs would not release 2,810,000 coho salmon juveniles, as under existing conditions, and the additional 600,000 juvenile coho salmon produced by the new FRF coho salmon program under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all genetic effects (within-population genetic diversity and hatchery-influenced selection) on natural-origin coho salmon from hatchery-origin coho salmon associated with the ongoing and proposed new programs would be discontinued relative to existing conditions, Alternative 1, and Alternative 2, and theoretically may diminish over time as traits in the combined population trend back toward natural-origin characteristics, though as stated above in Subsection 3.2.3.1, Genetics, this theory is untested. No natural-origin coho salmon would be collected for hatchery broodstock, and over time, once all of the coho salmon from previous hatchery releases in the river basin have returned, there would be no hatchery-origin coho salmon returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, the elimination of all the coho salmon programs overall would have a moderate positive genetic effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 30) because all genetic effects (within-population genetic diversity and hatchery-influenced selection) on natural-origin coho salmon from the hatchery programs would be eliminated, relative to Alternative 1 and Alternative 2 (which would both have a moderate negative effect) and to existing conditions (which has a low negative effect).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2. The Soos Creek, Keta, Creek, and Marine Technology Center coho salmon programs would release 1,105,000 fewer fish than under existing conditions, and 300,000 fewer fish would be released from the new FRF coho salmon hatchery program than under Alternative 1 and Alternative 2 (Table 28). The total number of hatchery-origin coho salmon released under Alternative 4 would be 1,705,000 juveniles, compared to 2,810,000 juveniles under existing conditions, 3,410,000 juveniles under Alternative 1 and Alternative 2, and no releases from the programs under Alternative 3 (Table 28).

Under Alternative 4, overall genetic effects (reduced genetic diversity and increased hatchery-influenced selection) from the coho salmon hatchery programs would be expected to be less than under Alternative 1 and Alternative 2, because although the broodstock used for the four programs would be of local origin and 50 percent fewer fish would be released, release numbers would be still be substantial (Table 28). Under Alternative 4, as under Alternative 1 and Alternative 2, the additional coho salmon juveniles that would be released from the new FRF coho salmon program (Table 28) would increase genetic effects (reduced genetic diversity and increased hatchery-influenced selection) on natural-origin coho salmon compared to existing conditions, but to a lesser extent than under Alternative 1 and Alternative 2. As under Alternative 1 and Alternative 2, under Alternative 4 the genetic effects (reduced genetic diversity and increased hatchery-influenced selection) on natural-origin coho salmon associated with each of the two release scenarios for the FRF coho salmon program would be the same.

In summary, under Alternative 4, the four coho salmon programs overall would have a low negative genetic effect on natural-origin coho salmon, which would be the same as under existing conditions, but would be less than under Alternative 1 and Alternative 2 (moderate negative) (Table 30), primarily because of reduced genetic effects on genetic diversity and hatchery-influenced selection associated with the reduced program size. The negative genetic effect under Alternative 4 (low negative) would be greater than the genetic effect under Alternative 3 (moderate positive) (Table 30) because the programs would be terminated and all genetic effects (genetic diversity and hatchery-influenced selection) on natural-origin coho salmon from hatchery-origin coho salmon associated with the ongoing and proposed new coho salmon programs would be eliminated.

4.2.1.4 Chum Salmon

There is one existing chum salmon hatchery program in the Duwamish-Green River Basin (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). The existing Keta Creek chum salmon program is an integrated program, and fish released from this program are intended to be genetically similar to the natural-origin chum salmon that spawn naturally in the Green River and its tributaries. Broodstock used for the large existing program (5,000,000 juveniles) were derived in part from the natural-origin Green River chum salmon population. Under existing conditions, the genetic risks of reduced genetic diversity by inadvertently reducing the effective breeding size and increased hatchery-influenced selection are ameliorated by the use of local broodstock, rearing of the fish for only a short time in the hatchery, and the substantial fidelity of returning adults to their release sites (Subsection 3.2.3.1, Genetics).

In summary, the existing chum salmon hatchery program has a low negative genetic effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 30), primarily because, although the size of the program is large, the genetic effects on genetic diversity and hatchery-influenced selection are ameliorated by the use of local broodstock and the short amount of time the fish are reared in the hatchery (Subsection 3.2.3.1, Genetics).

Alternative 1: Under Alternative 1, the existing integrated Keta Creek chum salmon program would continue to operate as under existing conditions, and genetic effects of hatchery-influenced selection from the program on natural-origin chum salmon would be the same as under existing conditions. The hatchery program would continue to release 5,000,000 hatchery-origin chum salmon (Table 28).

In summary, under Alternative 1, the chum salmon hatchery program would have a low negative genetic effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 30), which would be the same as under existing conditions, primarily because, although the size of the program is large (5,000,000 fish), the genetic effects (reduced genetic diversity and increased hatchery-influenced selection) would be ameliorated by the use of local broodstock and the short time the fish would be reared in the hatchery.

Alternative 2: Under Alternative 2, the chum salmon hatchery program would operate as under Alternative 1. Releases of hatchery-origin chum salmon would be 5,000,000 juveniles, which is the same as under existing conditions and Alternative 1 (Table 28). Genetic effects of the hatchery program on natural-origin chum salmon (reduced genetic diversity and increased hatchery-influenced selection) would be the same as under existing conditions and Alternative 1.

In summary, under Alternative 2, the chum salmon hatchery program would have a low negative genetic effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 30), which would be the same as under existing conditions and Alternative 1, primarily because, although the size of the program is large (5,000,000 fish), the genetic effects (reduced genetic diversity and increased hatchery-influenced selection) would be ameliorated by the use of local broodstock and the short time the fish would be reared in the hatchery.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and the Keta Creek chum salmon hatchery program would not release 5,000,000 juveniles as under existing conditions, Alternative 1, and Alternative 2 (Table 27). Therefore, all genetic effects (genetic diversity and hatchery-influenced selection) on natural-origin chum salmon associated with the chum salmon hatchery programs would be discontinued relative to existing conditions, Alternative 1, and Alternative 2, and theoretically may diminish over time as traits in the combined population trend back toward natural-origin characteristics, though as stated above in Subsection 3.2.3.1, Genetics, this theory is untested. No natural-origin chum salmon would be collected for hatchery broodstock, and over time, once all of the chum salmon from previous hatchery releases in the river basin have returned, there would be no hatchery-origin chum salmon returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin hatchery programs.

In summary, under Alternative 3, the elimination of the chum salmon program would have a low positive genetic effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 30) because all genetic effects (genetic diversity and hatchery-influenced selection) on natural-origin chum salmon from the hatchery program would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which all would have a low negative genetic effect).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to existing conditions, Alternative 1, and Alternative 2, and the Keta Creek chum salmon program would release 2,500,000 fewer fish than under existing conditions, Alternative 1, and Alternative 2 (Table 28). The total number of hatchery-origin chum salmon released under Alternative 4 would be 2,500,000 juveniles, compared to 5,000,000 juveniles under existing conditions, Alternative 1, and Alternative 2, and no releases from the programs under Alternative 3 (Table 28).

Under Alternative 4, overall genetic effects (reduced genetic diversity and increased hatchery-influenced selection) from the chum salmon hatchery program would be expected to be less than under existing conditions, Alternative 1, and Alternative 2 because, although the broodstock used for the program would be of local origin, and 50 percent fewer fish would be released (Table 28), the release numbers would still be substantial.

In summary, under Alternative 4, the chum salmon program overall would have a low negative genetic effect on natural-origin chum salmon in the Duwamish-Green River Basin, which would be the same as under existing conditions, Alternative 1, and Alternative 2 (Table 30), primarily because the genetic effects of reduced genetic diversity and increased hatchery-influenced selection associated with the relatively large number of fish released. The negative genetic effect under Alternative 4 (low negative) would be greater than the genetic effect under Alternative 3 (low positive) (Table 30), under which the hatchery programs would be terminated and all genetic effects (reduced genetic diversity and increased hatchery-influenced selection) on natural-origin chum salmon from hatchery-origin chum salmon associated with the hatchery program would be eliminated.

4.2.2 Competition and Predation

Competition and predation from hatchery-origin salmon and steelhead on natural-origin salmon and steelhead occurs in both fresh water and marine areas, and occurs among all salmon and steelhead species as juveniles (Subsection 3.2.3.2, Competition and Predation). Competition for food and space may occur at juvenile life stages when similarly-sized hatchery-origin species overlap in time and space with natural-origin fish and compete for habitat, food, or cover, and at adult life stages when spawners compete for spawning sites. Predation may occur when species overlap in time and space and there are substantial differences in fish size (e.g., hatchery-origin fish are at least one-third larger than their natural-origin counterparts), when large numbers of hatchery-origin fish are released compared to natural-origin fish present in the release area, and when salmon and steelhead residualize in fresh water (Subsection 3.2.3.2, Competition and Predation). Depending on the species and circumstances, competition and predation can lead to mortalities that affect the abundance and productivity of natural-origin fish. As described in Subsection 3.2.3.2, Competition and Predation, effects from competition are reduced by using practices associated with release timing, fish size, and release location, such as avoiding releasing hatchery-origin fish during the peak downstream migration period of natural-origin fish to avoid temporal overlaps, releasing hatchery-origin fish that are ready to quickly migrate downstream to minimize the length of time during which hatchery-origin and natural-origin fish might interact, and releasing hatchery-origin fish in locations different from locations where natural-origin fish spawn to avoid spawning area competition from hatchery-origin fish. Effects from predation are reduced by not releasing larger fish in areas where they would have the opportunity to feed on smaller natural-origin salmon and steelhead, and avoiding releases of hatchery-origin fish that are likely to residualize. Competition and predation effects on natural-origin salmon and steelhead associated with the hatchery programs in the Duwamish-Green River Basin under the alternatives are described below.

4.2.2.1 Chinook Salmon

Competition – Fall-run Chinook salmon, steelhead, coho salmon, and chum salmon produced by hatchery programs in the Duwamish-Green River Basin may compete for food and space with natural-origin fall-run Chinook salmon when the fish are of similar size and occupy the same areas (Subsection 3.2.3.2, Competition and Predation), resulting in some mortality of natural-origin fall-run Chinook salmon. The Soos Creek fall-run Chinook program poses competition risks because of the relatively large number of subyearlings released (up to 4,200,000) (Table 3), the similarity in size of the subyearlings to natural-origin fall-run Chinook salmon parr outmigrants (Table 15), and the release of subyearlings relatively high in the watershed. In addition, the two steelhead hatchery programs release a modest number of yearlings (total of 133,000 fish), whereas the Soos Creek and Keta Creek coho salmon programs combined release a substantial number of coho salmon yearlings (2,680,000 fish). Although the sizes of these yearlings are somewhat larger than natural-origin fall-run Chinook salmon yearlings, thus lessening the likelihood of competition, the hatchery-origin fish are released at similar times (Table 15) and occupy the same freshwater areas during outmigration as natural-origin fall-run Chinook salmon, which presents a competition risk. Finally, chum salmon fry released from the Keta Creek chum salmon program, although smaller in size than natural-origin fall-run Chinook salmon subyearlings, pose a competition risk because of the large number of chum salmon that are released (5,000,000 fish) (Table 28), the release location that is relatively high in the river basin, and the overlap in timing of release and outmigration with natural-origin fall-run Chinook salmon (Table 15). Due to differences in spawning times between natural-origin fall-run Chinook salmon and hatchery-origin fall-run Chinook salmon, competition for spawning sites is considered unlikely. Competition with natural-origin fall-run Chinook salmon may also occur in estuarine and marine areas, which may also result in some mortality of natural-origin fall-run Chinook salmon, but the extent of such interactions is generally unknown. Any such competition likely occurs primarily in estuarine areas adjacent to the river mouth where hatchery-origin fish may concentrate on their migration to marine waters.

In summary, considering all potential risks of competition for food and space, the existing salmon and steelhead hatchery programs overall have a moderate negative competition effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 31), primarily because of the potential for mortality from competition in fresh water for food and space associated with the large numbers of fish released (e.g., fall-run Chinook salmon subyearlings, coho salmon yearlings, and chum salmon fry) and their up-river release locations (Subsection 3.2.3.2, Competition and Predation).

Table 31. Comparative summary of competition effects on natural-origin salmon and steelhead under the alternatives.

Natural-origin Species	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Fall-run Chinook Salmon	Moderate negative	High negative	High negative	High positive	Low negative
Steelhead	Moderate negative	High negative	High negative	High positive	Moderate negative
Coho Salmon	Moderate negative	High negative	High negative	High positive	Moderate negative
Chum Salmon	Negligible negative	Negligible negative	Negligible negative	Negligible positive	Negligible negative
Pink Salmon	Negligible negative	Negligible negative	Negligible negative	Negligible positive	Negligible negative

Alternative 1 - Competition: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions (Subsection 3.2.3.2, Competition and Predation). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from the three new FRF hatchery programs. This would increase the total number of juveniles released under Alternative 1 by 14 percent to 13,993,000 fish, compared to 12,443,000 fish under existing conditions (Table 28). As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery programs, associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as fall-run Chinook salmon subyearlings, steelhead yearlings, and coho salmon yearlings, below the dam with no passage; or 17 percent released as Chinook salmon subyearlings, steelhead yearlings and coho salmon yearlings below the dam and 83 percent released as Chinook salmon, steelhead, and coho salmon fry above the dam with passage). Compared to existing conditions, the additional hatchery-origin juveniles from the FRF hatchery programs would increase competition for food and space with natural-origin fall-run Chinook salmon primarily because the additional FRF hatchery-origin fish would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin fall-run Chinook salmon. Competition for food and space associated with the two release scenarios (Table 27) from the FRF hatchery programs on natural-origin fall-run Chinook salmon would be similar, except that under the passage scenario, releases of smaller fish (fry) in the watershed above Howard Hanson Dam would increase the length of time that the hatchery-origin fish would compete with natural-origin fall-run Chinook salmon within the Duwamish-Green River Basin. Competition for food and space with natural-origin fall-run Chinook salmon may also occur in estuarine and marine areas, but the extent of such interactions is generally unknown. Any such competition would likely occur primarily in estuarine areas adjacent to the river mouth where hatchery-origin fish may concentrate on their migration to marine waters.

In summary, under Alternative 1, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a high negative competition effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 31), which would be greater than under existing conditions (moderate negative), primarily because of the increased potential for mortality from competition for food and space associated with the additional production of hatchery-origin fish from the new FRF hatchery programs, which do not occur under existing conditions. Releases of hatchery-origin fish would occur high in the river basin and would occur at similar times and occupy similar freshwater areas the as natural-origin fall-run Chinook salmon during outmigration.

Alternative 2 - Competition: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would total 13,993,000 juveniles, which would be same as under Alternative 1 (Table 28). Competition for food and space from those releases on natural-origin fall-run Chinook salmon would be the same as under Alternative 1, and would result from competition with Chinook salmon, steelhead, and coho salmon that are similar in size to natural-origin fall-run Chinook salmon and would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin fall-run Chinook salmon (Subsection 3.2.3.2, Competition and Predation). Competition for food and space from the two release scenarios from the new FRF hatchery programs (Table 27) on natural-origin fall-run Chinook salmon would be the same as under Alternative 1. In addition, although somewhat smaller in size than natural-origin fall-run Chinook salmon outmigrants, hatchery-origin chum salmon fry would contribute to the competition risk to natural-origin fall-run Chinook salmon because of the substantial number of chum salmon fry that would be released (5,000,000 chum salmon fry) from locations relatively high in the river basin and the overall timing of release during outmigration of natural-origin fall-run Chinook salmon. Competition for food and space from FRF releases either above or below the dam would be the same as described under Alternative 1.

In summary, under Alternative 2, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a high negative competition effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 31), which would be the same as under Alternative 1 because the releases would be the same. Competition effects under Alternative 2 would increase compared to existing conditions (moderate negative) (Table 31) because of the increased potential for mortality from competition for food and space associated with the additional production of hatchery-origin fish from the new FRF hatchery programs, which do not occur under existing conditions. Releases of hatchery-origin fish would occur high in the river basin and would occur at similar times and occupy similar freshwater areas as natural-origin fall-run Chinook salmon during outmigration.

Alternative 3 - Competition: Under Alternative 3, the salmon and steelhead hatchery programs in the Duwamish-Green River Basin would be terminated, and juvenile salmon and steelhead would not be released (Table 28). Therefore, all competition for food and space with natural-origin fall-run Chinook salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the salmon and steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin salmon and steelhead returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential competition risks, the elimination of the salmon and steelhead programs overall would have a high positive competition effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 31), primarily because all mortality from competition for food and space with natural-origin fall-run Chinook salmon from the hatchery programs would be eliminated, relative to Alternative 1 and Alternative 2 (which would both have a high negative competition effect) and existing conditions (which has a moderate negative competition effect).

Alternative 4 - Competition: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release 5,446,500 fewer fish than under existing conditions and 775,000 fewer fish from the new FRF salmon and steelhead hatchery programs than under Alternative 1 and Alternative 2 (Table 28). The total number of hatchery-origin salmon and steelhead released under Alternative 4 would be 6,9496,500 juveniles, compared to 12,43,000 juveniles under existing conditions, 13,993,000 juveniles under Alternative 1 and Alternative 2, and no hatchery releases under Alternative 3 (Table 28).

Considering overall competition effects from the salmon and steelhead hatchery programs under Alternative 4, relative to Alternative 1, Alternative 2, and existing conditions, competition for food and space with natural-origin fall-run Chinook salmon from similarly sized hatchery-origin fall-run Chinook salmon, steelhead, coho salmon and chum salmon fry in both fresh water and marine water, would be less because substantially fewer fish would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin fall-run Chinook salmon. Under Alternative 4, as under Alternative 1 and Alternative 2, salmon and steelhead juveniles would be released from the new FRF salmon and steelhead programs (Table 28) and would increase competition for food and space with natural-origin fall-run Chinook salmon compared to existing conditions, but FRF releases under Alternative 4 would be less than under Alternative 1 and Alternative 2. As under Alternative 1 and Alternative 2, under Alternative 4 competition for food and space associated with the two release scenarios (Table 27) from the FRF hatchery programs on natural-origin fall-run Chinook salmon would be similar, except that under the passage scenario, releases of smaller fish (fry) in the watershed above Howard Hanson Dam would increase the length of time that the hatchery-origin fish would compete with natural-origin fall-run Chinook salmon within the Duwamish-Green River Basin.

In summary, under Alternative 4, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a low negative competition effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 31), which would be less than under Alternative 1 and Alternative 2 (high negative) and existing conditions (moderate negative). This is because there would be less potential for mortality to natural-origin fall-run Chinook salmon from competition for food and space from the reduced number of hatchery-origin salmon and steelhead that would be produced under Alternative 4. Competition for food and space would occur from similarly sized hatchery-origin fall-run Chinook salmon, steelhead, coho salmon, and chum salmon released high in the river basin at the same time and occupying the same freshwater areas during outmigration as natural-origin fall-run Chinook salmon. In comparison to Alternative 3 (high positive), under which the hatchery programs would be terminated, competition for food and space under Alternative 4 would be increased because there would be no potential for mortality to natural-origin fall-run Chinook salmon from competition with hatchery-origin fish from the programs under Alternative 3.

Predation – Fall-run Chinook salmon, steelhead, and coho salmon released as yearlings by hatchery programs in the Duwamish-Green River Basin are potential predators of natural-origin fall-run Chinook salmon subyearlings (Subsection 3.2.3.2, Competition and Predation). Predation risks to natural-origin fish occur when the hatchery-origin fish are at least 50 percent larger and occur at the same time and place as natural-origin fish. Yearlings released from the hatchery programs are substantially larger in size than the co-occurring natural-origin fall-run Chinook salmon subyearlings, the number of hatchery-origin yearlings released is substantial, the release timing of hatchery-origin yearlings is similar to the outmigration timing of natural-origin fall-run Chinook salmon, and the hatchery-origin yearlings are released high in the watershed; these factors collectively make natural-origin fall-run Chinook salmon subyearlings potential prey for hatchery-origin yearlings as the fish out-migrate seaward. Releases of coho salmon yearlings from the relatively small Marine Technology Center hatchery program (10,000 yearlings) do not pose substantial predation risks to natural-origin fall-run Chinook salmon because releases from the program are not made into natural-origin fall-run Chinook salmon production areas. Although predation on natural-origin fall-run Chinook salmon by co-occurring yearling releases may also occur in estuarine and marine areas, the extent of such interactions is generally unknown. Any such predation likely occurs primarily in estuarine areas adjacent to the river mouth where hatchery-origin fish may concentrate for a time on their migration to marine waters, although yearling hatchery-origin fish likely disperse promptly into marine waters (Subsection 3.2.3.2, Competition and Predation).

In summary, considering all potential predation risks, the existing salmon and steelhead hatchery programs overall have a high negative predation effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 32), primarily because of the potential for mortality from hatchery-origin fish predation in fresh water on smaller-sized natural-origin fall-run Chinook salmon associated with the substantial numbers of hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings and their up-river release locations and release timing, leading to spatial and temporal overlap during outmigration (Subsection 3.2.3.2, Competition and Predation).

Alternative 1 – Predation: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions, and a total of 3,113,000 fall-run Chinook salmon, steelhead, and coho salmon yearlings would be released (Subsection 3.2.3.2, Competition and Predation). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from the three new FRF hatchery programs (Table 28). As shown in Table 27, there would be two different release scenarios for hatchery-origin fish from the new FRF hatchery programs associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as fall-run Chinook salmon subyearlings, steelhead yearlings, and coho salmon yearlings, below the dam with no passage; or 17 percent released as Chinook salmon subyearlings, steelhead yearlings, and coho salmon yearlings below the dam and 83 percent released as Chinook salmon, steelhead, and coho salmon fry above the dam with passage). Without passage at the dam, the new FRF hatchery programs would release 950,000 steelhead and coho salmon yearlings below the dam, whereas with passage 170,000 steelhead and coho salmon yearlings would be released below the dam; no yearlings would be released above the dam under either scenario (Table 27).

Table 32. Comparative summary of predation effects on natural-origin salmon and steelhead under the alternatives.

Natural-origin Species	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Fall-run Chinook Salmon	High negative	High negative	High negative	High positive	Moderate negative
Steelhead	Negligible negative	Negligible negative	Negligible negative	Negligible positive	Negligible negative
Coho Salmon	Negligible negative	Negligible negative	Negligible negative	Negligible positive	Negligible negative
Chum Salmon	Low negative	Moderate negative	Moderate negative	Moderate positive	Low negative
Pink Salmon	Low negative	Moderate negative	Moderate negative	Moderate positive	Low negative

Under Alternative 1, 4,063,000 fall-run Chinook salmon yearlings, steelhead yearlings, and coho salmon yearlings would be released without passage at the dam, or 3,283,000 yearlings would be released with passage at the dam (Table 3). Because of their larger size, the salmon and steelhead yearlings may prey on co-occurring smaller natural-origin fall-run Chinook salmon. Compared to existing conditions under which there are no FRF hatchery programs, the additional releases of hatchery-origin steelhead and coho salmon yearlings from the FRF hatchery programs under Alternative 1 would increase predation on natural-origin fall-run Chinook salmon, especially without passage at Howard Hanson dam, primarily because the larger releases of yearlings below the dam would increase the distance and length of time during which the larger hatchery-origin fish could prey on smaller natural-origin fall-run Chinook salmon within the Duwamish-Green River Basin. Predation on natural-origin fall-run Chinook salmon by hatchery-origin yearlings may also occur in estuarine and marine areas, but the extent of such interactions is generally unknown. Any such predation would likely occur primarily in estuarine areas adjacent to the river mouth where hatchery-origin fish may concentrate on their migration to marine waters.

In summary, under Alternative 1, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a high negative predation effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 32), which would be same as under existing conditions, primarily because of the potential for mortality from hatchery-origin yearling fall-run Chinook salmon, steelhead, and coho salmon that would be released relatively high in the watershed and may prey on smaller sized natural-origin fall-run Chinook salmon during outmigration. The increased production associated with the new FRF hatchery programs would increase the already high negative predation effect (the highest category of effect) (Table 32), primarily because of the substantial number and large size of yearlings that would be released high in the watershed below Howard Hanson Dam that may prey on smaller natural-origin fall-run Chinook salmon during outmigration.

Alternative 2 – Predation: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of yearling hatchery-origin salmon and steelhead from the programs would total 4,063,000 fish without passage at the dam, or 3,283,000 fish with passage at the dam (Table 3), which would be the same as under Alternative 1. Predation on natural-origin fall-run Chinook salmon from those releases would be the same as under Alternative 1 and would result from predation by fall-run Chinook salmon, steelhead, and coho salmon yearlings that are larger in size and would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin fall-run Chinook salmon (Subsection 3.2.3.2, Competition and Predation). Predation on natural-origin fall-run Chinook salmon under the two release scenarios for the new FRF hatchery programs (Table 27) would be the same as under Alternative 1. As under Alternative 1, predation on natural-origin fall-run Chinook salmon by hatchery-origin yearlings may also occur in estuarine and marine areas, but the extent of such interactions is generally unknown. Any such predation would likely occur primarily in estuarine areas adjacent to the river mouth where hatchery-origin fish may concentrate on their migration to marine waters.

In summary, under Alternative 2, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a high negative predation effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 32), which would be the same as under Alternative 1 and existing conditions, primarily because of the potential for mortality from hatchery-origin yearling fall-run Chinook salmon, steelhead, and coho salmon that would be released relatively high in the watershed that may prey on smaller sized natural-origin fall-run Chinook salmon during outmigration. The increased production associated with the new FRF hatchery programs would increase the already high negative predation effect (the highest category of effect) (Table 32), primarily because of the increased potential for mortality from the substantial number and large size of yearlings that would be released high in the watershed below Howard Hanson Dam that may prey on smaller natural-origin fall-run Chinook salmon during outmigration.

Alternative 3 – Predation: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release 3,113,000 salmon and steelhead yearlings as under existing conditions. In addition, 170,000 to 970,000 steelhead and coho salmon yearlings would not be produced by the new FRF hatchery programs as under Alternative 1 and Alternative 2 (Table 28). Therefore, all predation on natural-origin fall-run Chinook salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the salmon and steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin salmon and steelhead returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential predation risks, the elimination of the salmon and steelhead programs overall would have a high positive predation effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 32) because all mortality from predation on natural-origin fall-run Chinook salmon from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which would all have a high negative predation effect).

Alternative 4 – Predation: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release 1,556,500 fewer yearlings than under existing conditions. For the new FRF salmon and steelhead programs, 85,000 fewer yearlings would be released with passage at Howard Hanson Dam, or 425,000 fewer yearlings would be released without fish passage at the dam, compared to Alternative 1 and Alternative 2 (Table 28). Under Alternative 4, 2,531,500 fall-run Chinook salmon, steelhead, and coho salmon yearlings would be released without passage at the dam, or 2,141,500 yearlings would be released with passage at the dam (Table 3). These releases of larger salmon and steelhead yearlings would pose predation risks to smaller natural-origin fall-run Chinook salmon. Compared to existing conditions under which there are no FRF hatchery programs, the additional releases of hatchery-origin steelhead and coho salmon yearlings from the FRF hatchery programs under Alternative 4 would increase predation risks to natural-origin fall-run Chinook salmon, especially without passage, primarily because the larger releases of yearlings below Howard Hanson Dam would increase the distance and length of time during which the larger hatchery-origin fish could prey on smaller natural-origin fall-run Chinook salmon within the Duwamish-Green River Basin. Predation on natural-origin fall-run Chinook salmon may also occur in estuarine and marine areas, but the extent of such interactions is generally unknown. It is likely that any such predation would occur primarily in estuarine areas adjacent to the river mouth where hatchery-origin fish may concentrate on their migration to marine waters.

Considering overall predation from the salmon and steelhead hatchery programs under Alternative 4, relative to existing conditions, Alternative 1, and Alternative 2, predation on natural-origin fall-run Chinook salmon by larger yearling hatchery-origin Chinook salmon, steelhead, and coho salmon in both fresh water and marine water would be less because substantially fewer fish would be released at the same time and occupy the same freshwater areas during outmigration of natural-origin fall-run Chinook salmon. Under Alternative 4, as under Alternative 1 and Alternative 2, salmon and steelhead yearlings would be released from the new FRF salmon and steelhead programs (Table 28), and would increase predation on natural-origin fall-run Chinook salmon compared to existing conditions, but FRF releases under Alternative 4 would less than under Alternative 1 and Alternative 2. As under Alternative 1 and Alternative 2, under Alternative 4 predation associated with the two release scenarios (Table 27) from the FRF hatchery programs on natural-origin fall-run Chinook salmon would be greater than under existing conditions.

In summary, under Alternative 4, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a moderate negative predation effect on natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 32), which would be less than under existing conditions, Alternative 1, and Alternative 2 (high negative). This is because there would be less potential for mortality to natural-origin fall-run Chinook salmon from predation due to the decreased number of hatchery-origin Chinook salmon, steelhead, and coho salmon yearlings that would be produced under Alternative 4. Predation would occur from larger hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon released high in the river basin at the same time and occupying the same areas during outmigration as natural-origin fall-run Chinook salmon. In comparison to Alternative 3 (high positive) under which the hatchery programs would be terminated, predation under Alternative 4 would be increased because there would be no potential for mortality to natural-origin fall-run Chinook salmon from predation by hatchery-origin fish from the programs under Alternative 3.

4.2.2.2 Steelhead

Competition - Releases of yearling Chinook salmon, steelhead, and coho salmon produced by hatchery programs in the Duwamish-Green River Basin compete for food and space with natural-origin steelhead (Subsection 3.2.3.2, Competition and Predation) because of the similarity in size of the hatchery-origin yearlings, similarity in timing of releases and outmigration of natural-origin steelhead smolts, locations of releases that are relatively high in the watershed, and the substantial number of yearlings released. This competition may result in some mortality of natural-origin steelhead. Of the total of 3,113,000 yearlings produced annually under existing conditions, up to 300,000 are produced from the Soos Creek fall-run Chinook salmon program, up to 133,000 are produced from the Green River late winter-run and Soos Creek summer-run steelhead programs, and up to 2,680,000 are produced from the Soos Creek and Keta Creek coho salmon programs (Table 3). Over half of the yearlings from the Soos Creek and Keta Creek coho salmon programs are transferred to marine net pens for release, eliminating competition for food and space in fresh water from those releases. Hatchery releases of fall-run Chinook salmon subyearlings, coho salmon fry, and chum salmon fry do not compete with natural-origin steelhead due to the small size of the fish released compared to the larger size of natural-origin steelhead out-migrants. Although returning hatchery-origin steelhead adults may compete with natural-origin steelhead for spawning sites, the existing winter-run steelhead hatchery program is an integrated program whereby natural spawning by hatchery-origin adults is expected and not considered a substantial competition risk. Competition from hatchery-origin fish released in the Duwamish-Green River Basin with natural-origin steelhead may also occur in estuarine and marine areas, but the extent of such interactions is likely not substantial, primarily because once steelhead smolts enter the marine environment, they tend to move promptly through Puget Sound and beyond (Subsection 3.2.3.2, Competition and Predation).

In summary, considering all potential risks of competition for food and space and potential natural-origin juvenile steelhead mortality that could result, the existing salmon and steelhead hatchery programs overall have a moderate negative competition effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 31), primarily because of the potential for mortality from competition in fresh water for food and space associated with the large total number of released yearling fall-run Chinook salmon, steelhead, and coho salmon that are similar in size to natural-origin steelhead smolt outmigrants, and spatial and temporal overlap from the yearling releases that occur relatively high in the watershed (Subsection 3.2.3.2, Competition and Predation).

Alternative 1 - Competition: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions (Subsection 3.2.3.2, Competition and Predation) and would release up to 3,113,000 salmon and steelhead yearlings annually (Table 3). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from the three new FRF hatchery programs (Table 28). As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery programs, associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as fall-run Chinook salmon subyearlings, steelhead yearlings, and coho salmon yearlings [yearling releases would total up to 950,000 fish] below the dam with no passage; or 17 percent released as Chinook salmon subyearlings, steelhead yearlings, and coho salmon yearlings [yearling releases would total up to 170,000 fish] below the dam and 83 percent released as Chinook salmon, steelhead, and coho salmon fry above the dam with passage). Under Alternative 1, the total number of fall-run Chinook salmon, steelhead, and coho salmon yearlings released would be 4,063,000 fish without passage at the dam, or 3,283,000 fish with passage at the dam (Table 3). Compared to existing conditions, the hatchery-origin yearlings from the FRF hatchery programs would increase competition for food and space with natural-origin steelhead, primarily because the additional hatchery-origin fish would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin steelhead smolts. Competition associated with the two release scenarios (Table 27) from the FRF hatchery programs on natural-origin steelhead would be greater under the scenario without fish passage, because a substantially larger number of yearlings would be released below the dam, which would increase the distance and time that the hatchery-origin yearlings would compete for food and space with natural-origin steelhead outmigrants within the Duwamish-Green River Basin. Competition for food and space with natural-origin steelhead may also occur in estuarine and marine areas, but the extent of such interactions would likely not be substantial, primarily because once steelhead smolts enter the marine environment, they tend to move promptly through Puget Sound and beyond (Subsection 3.2.3.2, Competition and Predation).

In summary, under Alternative 1, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a high negative competition effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 31), which would be greater than under existing conditions (moderate negative), primarily because of the increased potential for mortality from competition for food and space in fresh water associated with the substantially larger total number of steelhead and coho salmon yearlings that would be released from the new FRF hatchery programs (especially without fish passage at the dam), which do not occur under existing conditions. Competition would result from releases of hatchery-origin yearlings similar in size to natural-origin steelhead smolt outmigrants and the spatial and temporal overlap from the yearling releases that would occur relatively high in the watershed.

Alternative 2 - Competition: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would be the same as under Alternative 1 (Table 28). Competition for food and space from those releases on natural-origin steelhead would be the same as under Alternative 1 and would result from competition with hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings that are similar in size to natural-origin steelhead, and that would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin steelhead (Subsection 3.2.3.2, Competition and Predation). Competition associated with the two release scenarios from the new FRF hatchery programs (Table 27) on natural-origin steelhead would be the same as under Alternative 1, whereby competition with natural-origin steelhead would be greater under the scenario without fish passage because a substantially larger number of yearlings would be released below the dam, which would increase the distance and time that the hatchery-origin yearlings would compete with natural-origin steelhead outmigrants within the Duwamish-Green River Basin. Competition for food and space with natural-origin steelhead may also occur in estuarine and marine areas, but the extent of such interactions would likely not be substantial, primarily because once steelhead smolts enter the marine environment, they tend to move promptly through Puget Sound and beyond (Subsection 3.2.3.2, Competition and Predation).

In summary, under Alternative 2, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a high negative competition effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 31), which would be the same as under Alternative 1 because the releases would be the same. Competition effects under Alternative 2 would be greater than under existing conditions (moderate negative), primarily because of the increased potential for mortality from competition for food and space in fresh water associated with the substantially larger total number of steelhead and coho salmon yearlings released from the new FRF hatchery programs (especially under the no fish passage scenario), which do not occur under existing conditions. Competition would result from releases of hatchery-origin yearlings similar in size to natural-origin steelhead smolt outmigrants and the spatial and temporal overlap from the yearling releases that would occur relatively high in the watershed.

Alternative 3 - Competition: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release 3,113,000 salmon and steelhead yearlings as under existing conditions (Table 28). In addition, 170,000 to 950,000 steelhead and coho salmon yearlings would not be produced by the new FRF hatchery programs as under Alternative 1 and Alternative 2 (Table 27). Therefore, all competition for food and space with natural-origin steelhead associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the salmon and steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin salmon and steelhead returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential competition risks, the elimination of the salmon and steelhead programs overall would have a high positive competition effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 31) because all mortality from competition for food and space with natural-origin steelhead from the hatchery programs would be eliminated relative to Alternative 1 and Alternative 2 (which would both have a high negative competition effect), and under existing conditions (which has a moderate negative competition effect).

Alternative 4 - Competition: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release 1,556,500 fewer fall-run Chinook salmon, steelhead, and coho salmon yearlings than under existing conditions, and 85,000 fewer coho salmon and steelhead yearlings from the new FRF hatchery programs with passage at Howard Hanson Dam, or 425,000 fewer yearlings without fish passage at the dam, than under Alternative 1 and Alternative 2 (Table 3, Table 28). Under Alternative 4, the total number of fall-run Chinook salmon, steelhead, and coho salmon yearlings released would be 2,031,500 fish without passage at the dam, or 1,641,500 fish with passage at the dam (Table 3). These releases of salmon and steelhead yearlings would compete for food and space with similarly sized natural-origin steelhead.

Under Alternative 4, competition for food and space from the yearling releases with natural-origin steelhead would be less than under Alternative 1 and Alternative 2, because fewer fish would be released that would be similar in size to natural-origin steelhead and that would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin steelhead. Compared to existing conditions, under which there are no FRF hatchery programs (Table 27), the releases of hatchery-origin steelhead and coho salmon yearlings from the FRF hatchery programs under Alternative 4 would increase competition risks to natural-origin fall-run Chinook salmon (especially under the no fish passage scenario), primarily because the larger releases of yearlings would increase the distance and length of time during which the hatchery-origin fish could compete with natural-origin steelhead within the Duwamish-Green River Basin. Competition for food and space with natural-origin steelhead may also occur in estuarine and marine areas, but the extent of such interactions would likely not be substantial, primarily because once steelhead smolts enter the marine environment, they tend to move promptly through Puget Sound and beyond (Subsection 3.2.3.2, Competition and Predation).

In summary, under Alternative 4, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a moderate negative competition effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 31), which would be the same as under existing conditions but less than under Alternative 1 and Alternative 2 (high negative). This is because there would be less potential for mortality to natural-origin steelhead from competition for food and space from the reduced number of hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings that would be produced under Alternative 4. Competition for food and space would occur from similarly sized hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings released high in the river basin at the same time and occupying the same areas during outmigration as natural-origin steelhead. In comparison to Alternative 3 (high positive), under which the hatchery programs would be terminated, competition for food and space under Alternative 4 would be increased because there would be no potential for mortality to natural-origin steelhead from competition with hatchery-origin fish from the programs under Alternative 3.

Predation – Hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon produced by hatchery programs in the Duwamish-Green River Basin are unlikely to pose substantial direct or indirect predation risks to natural-origin steelhead in fresh water or marine water (Subsection 3.2.3.2, Competition and Predation). Predation risks to natural-origin fish occur when the hatchery-origin fish are at least 50 percent larger and occur at the same time and place as natural-origin fish. This is because releases of hatchery-origin salmon and steelhead do not occur when they may prey on smaller sized natural-origin steelhead fry, or when most natural-origin steelhead parr are present (Table 15). Although the outmigration period for natural-origin steelhead yearlings may be at a time when other hatchery-origin fish are released, the large size of the natural-origin steelhead outmigrants would preclude them from being prey of hatchery-origin salmon and steelhead yearlings in freshwater and marine areas.

In summary, considering all potential predation risks, the existing salmon and steelhead hatchery programs overall have a negligible negative predation effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 32), primarily because the potential for mortality is unsubstantial due to the large size of natural-origin steelhead outmigrants compared to hatchery-origin salmon and steelhead outmigrants and differences in the timing of outmigration between hatchery-origin and natural-origin steelhead in fresh water (Subsection 3.2.3.2, Competition and Predation).

Alternative 1 – Predation: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions (Subsection 3.2.3.2, Competition and Predation) and would release up to 3,113,000 salmon and steelhead yearlings annually (Table 3). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from the new FRF hatchery programs (Table 28). Without fish passage at Howard Hanson Dam, the new FRF hatchery programs would release a total of 950,000 steelhead and coho salmon yearlings below the dam, whereas a total of 170,000 steelhead and coho salmon yearlings would be released below the dam with passage; no yearlings would be released above the dam under either scenario (Table 27). Under Alternative 1, releases of hatchery-origin fish would not affect the predation risks to natural-origin steelhead compared to existing conditions because the additional hatchery-origin fish would not be large enough to prey on natural-origin steelhead outmigrants when the hatchery-origin fish overlap with natural-origin steelhead in time and space.

In summary, under Alternative 1, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a negligible negative predation effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 32), which would be the same as under existing conditions, primarily because the potential for mortality would be unsubstantial due to the large size of natural-origin steelhead outmigrants compared to hatchery-origin salmon and steelhead outmigrants, and differences in the timing of outmigration between hatchery-origin fish and natural-origin steelhead.

Alternative 2 – Predation: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would be same as under Alternative 1 (Table 28). Predation from those releases (including FRF yearling release scenarios) on natural-origin steelhead would be the same as under Alternative 1 because the hatchery-origin fish would not be large enough to prey on natural-origin steelhead outmigrants when the hatchery-origin fish overlap with natural-origin steelhead in time and space.

In summary, under Alternative 2, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a negligible negative predation effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 32), which would be the same as under existing conditions and Alternative 1 (negligible negative), primarily because the potential for mortality would be unsubstantial due to the large size of natural-origin steelhead outmigrants compared to hatchery-origin salmon and steelhead outmigrants and differences in the timing of outmigration between hatchery-origin fish and natural-origin steelhead.

Alternative 3 – Predation: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release 3,113,000 salmon and steelhead yearlings as under existing conditions (Table 3). In addition, 170,000 to 970,000 steelhead and coho salmon yearlings would not be produced by the new FRF hatchery programs as under Alternative 1 and Alternative 2 (Table 27). Therefore, all predation on natural-origin steelhead associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the salmon and steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin salmon and steelhead returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential predation risks, the elimination of the salmon and steelhead programs overall would have a negligible positive predation effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 32) because all mortality from predation on natural-origin steelhead from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which would all have a negligible negative predation effect).

Alternative 4 – Predation: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release 1,556,500 fewer yearlings than under existing conditions, and 85,000 fewer yearlings from the new FRF salmon and steelhead hatchery programs with passage at Howard Hanson Dam, or 425,000 fewer yearlings without fish passage at the dam, than under Alternative 1 and Alternative 2 (Table 3, Table 28). Under Alternative 4, predation from all hatchery releases (including FRF hatchery program yearling release scenarios) on natural-origin steelhead would be the same as under existing conditions, Alternative 1, and Alternative 2 because the hatchery-origin fish would not be large enough to prey on natural-origin steelhead outmigrants when the hatchery-origin fish overlap with the natural-origin steelhead in time and space.

In summary, under Alternative 4, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a negligible negative predation effect on natural-origin steelhead in the Duwamish-Green River Basin (Table 32), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because the potential for mortality would be unsubstantial since the hatchery-origin fish would not be large enough to prey on natural-origin steelhead outmigrants. In comparison to Alternative 3 (negligible positive), predation under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for the hatchery-origin salmon and steelhead from the hatchery programs to prey on natural-origin steelhead.

4.2.2.3 Coho Salmon

Competition – Releases of yearling fall-run Chinook salmon, steelhead, and coho salmon produced by hatchery programs in the Duwamish-Green River Basin compete for food and space with natural-origin coho salmon (Subsection 3.2.3.2, Competition and Predation) because of the similarity in size of the hatchery-origin yearlings, similarity in timing of releases with outmigration of natural-origin coho salmon smolts, release locations that are relatively high in the watershed, and the substantial number of yearlings released. Of the total of 3,113,000 yearlings produced annually under existing conditions, up to 300,000 are produced from the Soos Creek fall-run Chinook salmon program, up to 133,000 are produced from the Green River late winter-run and Soos Creek summer-run steelhead programs, and up to 2,680,000 are produced from the Soos Creek and Keta Creek coho salmon programs (Table 3). Over half of the yearlings from the Soos Creek and Keta Creek coho salmon programs are transferred to marine net pens for release, and releases from the Marine Technology Center program are made at Seahurst Park, collectively eliminating competition for food and space in fresh water associated with those releases. Hatchery releases of Chinook salmon subyearlings, coho salmon fry, and chum salmon fry do not compete with natural-origin coho salmon due to the small size of the fish released compared to the larger size of natural-origin coho salmon out-migrants. Competition for spawning sites may occur between hatchery-origin and natural-origin coho salmon; however, the coho salmon hatchery programs are integrated programs whereby natural spawning by hatchery-origin adults is expected and not considered a substantial competition risk. Competition from hatchery-origin fish released in the Duwamish-Green River Basin with natural-origin coho salmon may also occur in estuarine and marine areas, with the greatest potential risk from releases of hatchery-origin coho salmon that occur in similar areas and at similar times (Subsection 3.2.3.2, Competition and Predation).

In summary, considering all potential risks of competition for food and space, the existing salmon and steelhead hatchery programs overall would have a moderate negative competition effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 31), primarily because of the potential for mortality from competition in fresh water for food and space from released fall-run Chinook salmon, steelhead, and coho salmon yearlings, and to a lesser extent in marine areas from fall-run Chinook salmon and coho salmon yearlings, the relatively large total number of released fall-run Chinook salmon, steelhead, and coho salmon yearlings that are similar in size to natural-origin coho salmon smolt outmigrants, and the spatial and temporal overlap from the yearling releases that occur relatively high in the watershed.

Alternative 1 - Competition: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions (Subsection 3.2.3.2, Competition and Predation) and would release up to 3,113,000 salmon and steelhead yearlings annually (Table 3). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from the three new FRF hatchery programs (Table 28). As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery programs associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as fall-run Chinook salmon subyearlings, steelhead yearlings, and coho salmon yearlings [yearling releases would total up to 950,000 fish] below the dam with no passage; or 17 percent released as Chinook salmon subyearlings, steelhead yearlings, and coho salmon yearlings [yearling releases would total up to 170,000 fish] below the dam and 83 percent released as Chinook salmon, steelhead, and coho salmon fry above the dam with passage). Under Alternative 1, the total number of fall-run Chinook salmon, steelhead, and coho salmon yearlings released would be 4,063,000 fish without passage at the dam, or 3,283,000 fish with passage at the dam (Table 3). Compared to existing conditions, the hatchery-origin yearlings from the FRF hatchery programs would increase competition for food and space with natural-origin coho salmon primarily because the additional hatchery-origin fish would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin coho salmon smolts. Competition associated with the two release scenarios (Table 27) from the FRF hatchery programs on natural-origin coho salmon would be greater under the scenario without fish passage, because a substantially larger number of yearlings would be released below the dam, which would increase the distance and time that the hatchery-origin yearlings would compete for food and space with natural-origin coho salmon smolt outmigrants within the Duwamish-Green River Basin. Competition for food and space from releases of hatchery-origin coho salmon on natural-origin coho salmon may also occur in estuarine and marine areas (Subsection 3.2.3.2, Competition and Predation).

In summary, under Alternative 1, considering all potential competition risks, the salmon and steelhead hatchery programs would have a high negative competition effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 31), which would be greater than under existing conditions (moderate negative), primarily because of the increased potential for mortality from competition for food and space in fresh water associated with the substantially larger total number of steelhead and coho salmon yearlings released from the new FRF hatchery programs (especially under the no fish passage scenario), which do not occur under existing conditions. Competition would result from releases of hatchery-origin yearlings similar in size to natural-origin coho salmon smolt outmigrants, and the spatial and temporal overlap from the yearling releases that would occur relatively high in the watershed.

Alternative 2 - Competition: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would be same as under Alternative 1 (Table 28). Competition for food and space from those releases on natural-origin coho salmon would be the same as under Alternative 1, and would result from competition with hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings that are similar in size to natural-origin coho salmon and that would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin coho salmon (Subsection 3.2.3.2, Competition and Predation). Competition associated with the two release scenarios from the new FRF hatchery programs (Table 26) on natural-origin coho salmon would be the same as under Alternative 1, whereby competition with natural-origin coho salmon would be greater under the scenario without fish passage, because a substantially larger number of yearlings would be released below the dam, which would increase the distance and time that the hatchery-origin yearlings would compete with natural-origin coho salmon smolt outmigrants within the Duwamish-Green River Basin. Competition from releases of hatchery-origin coho salmon on natural-origin coho salmon may also occur in estuarine and marine areas (Subsection 3.2.3.2, Competition and Predation).

In summary, under Alternative 2, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a high negative competition effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 31), which would be the same as under Alternative 1 because the releases would be the same. Competition effects under Alternative 2 would be greater than under existing conditions (moderate negative), primarily because of the increased potential for mortality from competition for food and space in fresh water associated with the substantially larger total number of steelhead and coho salmon yearlings released from the new FRF hatchery programs (especially under the no fish passage scenario), which do not occur under existing conditions. Competition would result from releases of hatchery-origin yearlings similar in size to natural-origin coho salmon smolt outmigrants and the spatial and temporal overlap from the yearling releases that would occur relatively high in the watershed.

Alternative 3 - Competition: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release 3,113,000 salmon and steelhead yearlings as under existing conditions (Table 3). In addition, 170,000 to 950,000 steelhead and coho salmon yearlings would not be produced by the new FRF hatchery programs as under Alternative 1 and Alternative 2 (Table 27). Therefore, all competition for food and space with natural-origin coho salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the salmon and steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin salmon and steelhead returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential competition risks, the elimination of the salmon and steelhead programs overall would have a high positive competition effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 31) because all mortality from competition for food and space with natural-origin coho salmon from the hatchery programs would be eliminated, relative to Alternative 1 and Alternative 2 (which would both have a high negative competition effect), and under existing conditions (which has a moderate negative competition effect).

Alternative 4 - Competition: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release 1,556,500 fewer fall-run Chinook salmon, steelhead, and coho salmon yearlings than under existing conditions, and 85,000 fewer coho salmon and steelhead yearlings from the new FRF hatchery programs with fish passage at Howard Hanson Dam, or 425,000 fewer yearlings without passage at the dam, than under Alternative 1 and Alternative 2 (Table 3, Table 27). Under Alternative 4, the total number of fall-run Chinook salmon, steelhead, and coho salmon yearlings released would be 2,031,500 fish without passage at the dam, or 1,641,500 fish with passage at the dam (Table 3). These releases of salmon and steelhead yearlings would compete with similarly sized natural-origin coho salmon. Under Alternative 4, competition for food and space from the yearling releases with natural-origin coho salmon would be less than under Alternative 1 and Alternative 2 because fewer fish would be released that would be similar in size to natural-origin coho salmon and that would be released at the same time and occupy the same freshwater areas during outmigration as natural-origin coho salmon. Compared to existing conditions, under which there are no FRF hatchery programs (Table 27), the releases of hatchery-origin steelhead and coho salmon yearlings from the FRF hatchery programs under Alternative 4 would increase competition risks to natural-origin coho salmon (especially under the no fish passage scenario), primarily because the larger releases of yearlings would increase the distance and length of time during which the hatchery-origin fish could compete with natural-origin coho salmon within the Duwamish-Green River Basin. Competition for food and space from releases of hatchery-origin coho salmon on natural-origin coho salmon may also occur in estuarine and marine areas (Subsection 3.2.3.2, Competition and Predation).

In summary, under Alternative 4, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a moderate negative competition effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 31), which would be the same as under existing conditions but less than under Alternative 1 and Alternative 2 (high negative). This is primarily because there would be less potential for mortality to natural-origin coho salmon from competition for food and space from the reduced number of hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings that would be produced under Alternative 4. Competition for food and space would occur from similarly-sized hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings released high in the river basin at the same time and occupying the same areas during outmigration as natural-origin coho salmon. In comparison to Alternative 3 (high positive) under which the hatchery programs would be terminated, competition for food and space under Alternative 4 would be increased because there would be no potential for mortality to natural-origin coho salmon from competition with hatchery-origin fish from the programs under Alternative 3.

Predation – Hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon produced by hatchery programs in the Duwamish-Green River Basin are unlikely to pose substantial direct or indirect predation risks to natural-origin coho salmon in fresh water or marine water (Subsection 3.2.3.2, Competition and Predation). Predation risks to natural-origin fish occur when the hatchery-origin fish are at least 50 percent larger and occur at the same time and place as natural-origin fish. Releases of hatchery-origin salmon and steelhead do not occur when small-sized natural-origin coho salmon fry are present or when most natural-origin coho salmon parr are present (Table 15). Although the out-migration period for natural-origin coho salmon yearlings may be at a time when other hatchery-origin fish are released, the large size of the natural-origin coho salmon outmigrants likely preclude hatchery-origin yearlings from preying on the coho salmon outmigrants in freshwater and marine areas.

In summary, considering all potential predation risks, the existing salmon and steelhead hatchery programs overall have a negligible negative predation effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 32), primarily because the potential for mortality is unsubstantial due to the large size of natural-origin coho salmon outmigrants in comparison to hatchery-origin salmon and steelhead, and outmigration timing differences between hatchery-origin fish and natural-origin coho salmon in fresh water (Subsection 3.2.3.2, Competition and Predation). There might be some predation from releases of hatchery-origin steelhead yearlings that overlap the outmigration timing of natural-origin coho salmon parr.

Alternative 1 – Predation: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions, and a total of 3,113,000 fall-run Chinook salmon, steelhead, and coho salmon yearlings would be released (Subsection 3.2.3.2, Competition and Predation). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from the new FRF hatchery programs (Table 28). Without fish passage at Howard Hanson Dam, the new FRF hatchery programs would release a total of 950,000 steelhead and coho salmon yearlings below the dam, whereas with passage a total of 170,000 steelhead and coho salmon yearlings would be released below the dam; no yearlings would be released above the dam under either scenario (Table 27). Under Alternative 1, releases of hatchery-origin fish either above or below Howard Hanson Dam would not affect the predation risks to natural-origin coho salmon compared to existing conditions because the additional hatchery-origin fish would not be large enough to prey on natural-origin coho salmon outmigrants when the hatchery-origin fish overlap with the natural-origin coho salmon in time and space.

In summary, under Alternative 1, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a negligible negative predation effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 32), which would be same as under existing conditions, primarily because the potential for mortality would be unsubstantial due to the large size of natural-origin coho salmon outmigrants compared to hatchery-origin salmon and steelhead outmigrants and differences in the timing of outmigration between hatchery-origin fish and natural-origin coho salmon.

Alternative 2 – Predation: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would be the same as under Alternative 1 (Table 28). Predation from those releases (including FRF yearling release scenarios) on natural-origin coho salmon would be the same as under Alternative 1 because the hatchery-origin fish would not be large enough to prey on natural-origin coho salmon outmigrants when the hatchery-origin fish overlap with the natural-origin coho salmon in time and space.

In summary, under Alternative 2, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a negligible negative predation effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 32), which would be same as under existing conditions and Alternative 1, primarily because the potential for mortality would be unsubstantial due to the large size of natural-origin coho salmon outmigrants compared to hatchery-origin salmon and steelhead outmigrants and differences in the timing of outmigration between hatchery-origin fish and natural-origin coho salmon.

Alternative 3 – Predation: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release 3,113,000 salmon and steelhead yearlings as under existing conditions (Table 3). In addition, 170,000 to 970,000 steelhead and coho salmon yearlings would not be produced by the new FRF hatchery programs as under Alternative 1 and Alternative 2 (Table 27). Therefore, all predation on natural-origin coho salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the salmon and steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin salmon and steelhead returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential predation risks, the elimination of the salmon and steelhead programs overall would have a negligible positive predation effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 32) because all mortality from predation on natural-origin coho salmon from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which would all have a negligible negative predation effect).

Alternative 4 – Predation: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release 1,556,500 fewer yearlings than under existing conditions, and 85,000 fewer yearlings from the new FRF salmon and steelhead hatchery programs with fish passage at Howard Hanson Dam, or 425,000 fewer yearlings without passage at the dam, than under Alternative 1 and Alternative 2 (Table 3, Table 27). Under Alternative 4, predation from all hatchery releases (including FRF hatchery program yearling release scenarios) on natural-origin coho salmon would be the same as under existing conditions, Alternative 1, and Alternative 2 because the hatchery-origin fish would not be large enough to prey on natural-origin coho salmon outmigrants when the hatchery-origin fish overlap with the natural-origin coho salmon in time and space.

In summary, under Alternative 4, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a negligible negative predation effect on natural-origin coho salmon in the Duwamish-Green River Basin (Table 32), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because the potential for mortality would be unsubstantial since the hatchery-origin fish would not be large enough to prey on natural-origin coho salmon outmigrants. In comparison to Alternative 3 (negligible positive), predation under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for the hatchery-origin salmon and steelhead from the hatchery programs to prey on natural-origin coho salmon.

4.2.2.4 Chum Salmon

Competition – Releases of hatchery-origin fall-run Chinook salmon, steelhead, and chum salmon produced by hatchery programs in the Duwamish-Green River Basin are unlikely to compete substantially for food and space with natural-origin chum salmon in fresh water or marine water (Subsection 3.2.3.2, Competition and Predation). This is because natural-origin chum salmon fry hatch and then out-migrate promptly to marine waters, spending relatively little time in fresh water. Although the Keta Creek chum salmon hatchery program produces a relatively large number of juveniles (up to 5,000,000 fry) (Table 3), the chum salmon releases compete minimally with natural-origin chum salmon because releases of hatchery-origin chum salmon (May) occur after the peak out-migration period of the similarly sized natural-origin chum salmon (April) (Table 15). In addition, hatchery-origin fall-run Chinook salmon subyearlings compete minimally with natural-origin chum salmon because hatchery-origin fall-run Chinook salmon subyearlings are released after the natural-origin chum salmon fry out-migration period (Table 15). Hatchery-origin steelhead and coho salmon yearlings and fall-run Chinook salmon juveniles would not be expected to compete with natural-origin chum salmon for food and space because of the substantially larger size of these three species compared to natural-origin chum salmon fry (Table 15). Thus, hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon are not considered competitors with natural-origin chum salmon fry. Competition for spawning sites between hatchery-origin and natural-origin chum salmon is also expected to be minimal because of spawning location differences (Subsection 3.2.3.2, Competition and Predation). The risk of competition from hatchery-origin chum salmon fry and the similarly sized natural-origin chum salmon fry is greatest in nearshore marine areas (Subsection 3.2.3.2, Competition and Predation), where the fish may congregate after out-migrating from freshwater. Releases of other hatchery-origin species are unlikely to compete with natural-origin chum salmon because of differences in fish size and spatial and temporal differences in out-migration behaviors and residence times (Subsection 3.2.3.2, Competition and Predation).

In summary, considering all potential risks of competition for food and space, the existing salmon and steelhead hatchery programs overall have a negligible negative competition effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 31), primarily because the potential for mortality from competition in nearshore marine areas for food and space associated with releases of hatchery-origin chum salmon fry would be unsubstantial, limited to the minimal extent they overlap in time and space with natural-origin chum salmon fry before they migrate to the ocean (Subsection 3.2.3.2, Competition and Predation).

Alternative 1 – Competition: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions (Subsection 3.2.3.2, Competition and Predation) and would release up to 12,443,000 salmon and steelhead annually, including up to 5,000,000 chum salmon fry (Table 28). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 fall-run Chinook salmon, steelhead, and coho salmon juveniles would be released from the three new FRF hatchery programs (Table 28). As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery programs associated with potential fish passage at Howard Hanson Dam. The new FRF hatchery programs and associated release scenarios would not pose competition risks to natural-origin chum salmon because the species produced from those programs are not considered competitors with natural-origin chum salmon (Subsection 3.2.3.2, Competition and Predation). The risk of competition for food and space with hatchery-origin chum salmon and the similarly sized natural-origin chum salmon would be greatest in nearshore marine areas, where the fish may congregate after out-migrating from freshwater.

In summary, under Alternative 1, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a negligible negative competition effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 31), which would be the same as under existing conditions, primarily because the potential for mortality from competition in nearshore marine areas for food and space associated with releases of hatchery-origin chum salmon fry would be unsubstantial, limited to the minimal extent they overlap in time and space with natural-origin chum salmon fry before they migrate to the ocean (Subsection 3.2.3.2, Competition and Predation). Additionally, there would be no change in releases of hatchery-origin chum salmon fry compared to existing conditions.

Alternative 2 – Competition: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would be the same as under Alternative 1 (Table 28). Competition for food and space from those releases with natural-origin chum salmon would be the same as under existing conditions and Alternative 1 and would result from competition between hatchery-origin chum salmon fry and natural-origin chum salmon fry in nearshore marine waters (Subsection 3.2.3.2, Competition and Predation).

In summary, under Alternative 2, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a negligible negative competition effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 31), which would be the same as under existing conditions and Alternative 1, primarily because the potential for mortality from competition in nearshore marine areas for food and space associated with releases of hatchery-origin chum salmon fry would be unsubstantial, limited to the minimal extent they overlap in time and space with natural-origin chum salmon fry before they migrate to the ocean (Subsection 3.2.3.2, Competition and Predation). Additionally, there would be no change in releases of hatchery-origin chum salmon fry compared to existing conditions and Alternative 1.

Alternative 3 - Competition: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release up to 12,443,000 salmon and steelhead as under existing conditions, including up to 5,000,000 chum salmon fry (Table 28), and the additional 1,550,000 salmon and steelhead juveniles produced by the new FRF hatchery programs under Alternative 1 and Alternative 2 (Table 28) would not be released. Therefore, all competition for food and space with natural-origin chum salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the salmon and steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin salmon and steelhead returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential competition risks, the elimination of the salmon and steelhead hatchery programs overall would have a negligible positive competition effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 31) because all mortality from competition for food and space with natural-origin chum salmon from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2, which would all have a negligible negative competition effect.

Alternative 4 - Competition: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release up to 6,996,500 fewer salmon and steelhead, including 2,500,000 fewer chum salmon fry (Table 28). Although substantially fewer hatchery-origin fish would be released under Alternative 4, the competition for food and space with natural-origin chum salmon would be the same as under existing conditions, Alternative 1, and Alternative 2 because of competition between hatchery-origin chum salmon fry and natural-origin chum salmon fry in nearshore marine waters (Subsection 3.2.3.2, Competition and Predation). In comparison to Alternative 3, competition under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for hatchery-origin salmon to compete with natural-origin chum salmon fry.

In summary, under Alternative 4, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a negligible negative competition effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 31), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because the potential for mortality from competition in nearshore marine areas for food and space associated with releases of hatchery-origin chum salmon fry would be unsubstantial, limited to the minimal extent they overlap in time and space with natural-origin chum salmon fry before they migrate to the ocean (Subsection 3.2.3.2, Competition and Predation). In comparison to Alternative 3, competition under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3 (which would have a negligible positive effect), thereby eliminating the potential for the hatchery-origin salmon and steelhead to compete with natural-origin chum salmon fry.

Predation – Hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon produced by hatchery programs in the Duwamish-Green River Basin pose direct and indirect predation risks to natural-origin chum salmon (Subsection 3.2.3.2, Competition and Predation), resulting in some mortality of natural-origin chum salmon. Predation risks to natural-origin fish occur when the hatchery-origin fish are at least 50 percent larger and occur at the same time and place as natural-origin fish. Hatchery-origin chum salmon fry are not predators of natural-origin chum salmon fry because of their similar size (Table 15). Predation on natural-origin chum salmon fry from hatchery releases are greatest when larger-sized hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings overlap in time and space with smaller natural-origin chum salmon fry (Subsection 3.2.3.2, Competition and Predation). Predation on natural-origin chum salmon fry by larger hatchery-origin fall-run Chinook salmon yearlings is of limited duration because the Chinook salmon yearlings disperse within a few weeks from river mouths and nearshore areas where natural-origin chum salmon fry initially congregate (Subsection 3.2.3.2, Competition and Predation). Predation on natural-origin chum salmon fry by hatchery-origin fall-run Chinook salmon subyearlings and steelhead yearlings is not expected because of differences between release times and areas in which the releases and natural-origin chum salmon fry occur, which limit potential predation risks. Hatchery-origin coho salmon yearlings are released during part of the peak out-migration of natural-origin chum salmon fry

(Table 15) and pose greater risk of predation to natural-origin chum salmon fry. Up to 2,680,000 hatchery-origin coho salmon yearlings are released annually (Table 28). Predation from hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings on natural-origin chum salmon fry in marine areas is unlikely because, although the hatchery-origin fish are larger than natural-origin chum salmon fry, the hatchery-origin fish likely disperse rapidly through nearshore areas and toward the ocean.

In summary, considering all potential predation risks, the existing salmon and steelhead hatchery programs overall have a low negative predation effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 32), primarily because of potential mortality of natural-origin chum salmon fry from predation in fresh water by large hatchery-origin coho salmon yearlings and to a lesser extent, Chinook salmon yearlings, and release timing of these hatchery-origin fish that occurs during the peak out-migration period of natural-origin chum salmon fry. However, the extent of predation is decreased because the area of overlap is relatively limited, and the chum salmon fry are expected to out-migrate rapidly from fresh water.

Alternative 1 – Predation: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions, and a total of 3,113,000 yearlings (300,000 fall-run Chinook salmon, 133,000 steelhead, and 2,680,000 coho salmon yearlings) would be released (Subsection 3.2.3.2, Competition and Predation). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from the new FRF hatchery programs (Table 27). Without fish passage at Howard Hanson Dam, the new FRF coho salmon program would release a total of 600,000 coho salmon yearlings below the dam, whereas with passage a total of 100,000 coho salmon yearlings would be released below the dam. The new FRF hatchery programs would not produce fall-Chinook yearlings and would not produce steelhead or coho salmon yearlings for release above the dam (Table 27). Under Alternative 1, the total number of hatchery-origin coho salmon yearlings released would be 3,280,000 fish without passage at the dam, or 2,780,000 fish with passage at the dam, and the total number of fall-run Chinook salmon yearlings released would be 300,000 (Table 3). Compared to existing conditions under which there are no FRF hatchery programs, the releases of hatchery-origin coho salmon yearlings from the new FRF coho salmon program under Alternative 1 would increase predation of natural-origin chum salmon, especially without fish passage, primarily because the larger number of coho salmon yearlings released below Howard Hanson Dam would increase predation by hatchery-origin coho salmon yearlings on smaller natural-origin chum salmon fry within the Duwamish-Green River Basin.

In summary, under Alternative 1, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a moderate negative predation effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 32), which would be greater than under existing conditions (low negative), primarily because of potential mortality from predation in fresh water associated with coho salmon yearlings released from the new FRF coho salmon program (especially under the no fish passage scenario), which would not occur under existing conditions.

Alternative 2 – Predation: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would be same as under Alternative 1 (Table 28). Predation from those releases on natural-origin chum salmon would be the same as under Alternative 1 and would result primarily from predation by hatchery-origin coho salmon yearlings, and to a lesser extent fall-run Chinook salmon yearlings that are larger than natural-origin chum salmon fry when the hatchery-origin fish overlap with natural-origin chum salmon fry in time and space (Subsection 3.2.3.2, Competition and Predation). Predation from the two release scenarios from the new FRF hatchery programs (Table 27) on natural-origin chum salmon fry would be the same as under Alternative 1, whereby predation on natural-origin chum salmon fry would be greater under the scenario without fish passage, because a larger number of hatchery-origin coho salmon yearlings would be released, which would increase predation on natural-origin chum salmon fry within the Duwamish-Green River Basin.

In summary, under Alternative 2, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a moderate negative predation effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 32), which would be the same as under Alternative 1, but greater than under existing conditions (low negative), primarily because of potential mortality from predation in fresh water associated with coho salmon yearlings released from the new FRF coho salmon program (especially under the no fish passage scenario), which would not occur under existing conditions.

Alternative 3 – Predation: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release 3,113,000 fall-run Chinook salmon, steelhead, and coho salmon yearlings as under existing conditions (Table 3). In addition, 100,000 to 600,000 coho salmon yearlings (depending on fish passage at Howard Hanson Dam) would not be produced by the new FRF coho salmon program as under Alternative 1 and Alternative 2 (Table 27). Therefore, all predation on natural-origin chum salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the salmon and steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin salmon and steelhead returning to or spawning in the river basin that were produced by hatchery programs in Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential predation risks, the elimination of the salmon and steelhead programs overall would have a moderate positive predation effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 32) because all mortality from predation on natural-origin chum salmon from the hatchery programs would be eliminated, relative to Alternative 1 and Alternative 2 (which would both have a moderate negative predation effect) and existing conditions (which has a low negative predation effect).

Alternative 4 – Predation: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release 150,000 fewer hatchery-origin fall-run Chinook salmon yearlings and 1,340,000 fewer coho salmon yearlings than under existing conditions, and 50,000 to 300,000 fewer coho salmon yearlings (depending on fish passage at Howard Hanson Dam) from the new FRF coho salmon program (Table 3, Table 27) than under Alternative 1 and Alternative 2. Under Alternative 4, a total of 150,000 hatchery-origin fall-run Chinook salmon and 1,390,000 to 1,640,000 coho salmon yearlings would be released (depending on fish passage at the dam). Under Alternative 4, predation from these yearling releases on natural-origin chum salmon fry would be less than under Alternative 1 and Alternative 2, but similar to predation under existing conditions because a similar number of yearling salmon would be released that would prey on natural-origin chum salmon fry.

In summary, under Alternative 4, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have low negative predation effect on natural-origin chum salmon in the Duwamish-Green River Basin (Table 32), which would be lower than under Alternative 1 and Alternative 2 (moderate negative), but the same as under existing conditions, primarily because of the potential mortality to natural-origin chum salmon fry from predation in fresh water from hatchery-origin coho salmon yearlings and to a lesser extent, fall-run Chinook salmon yearlings, and release timing of these hatchery-origin fish that would occur during the peak out-migration period of natural-origin chum salmon fry, although predation would be decreased because the area of overlap would be relatively limited, and the chum salmon fry would be expected to out-migrate rapidly from fresh water. In comparison to Alternative 3 (moderate positive), predation under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for the hatchery-origin salmon and steelhead to prey on natural-origin chum salmon fry.

4.2.2.5 Pink Salmon

Competition – There are no pink salmon hatchery programs in the Duwamish-Green River Basin. Like natural-origin chum salmon and fall-run Chinook salmon, natural-origin pink salmon have life histories involving short freshwater residence periods wherein they out-migrate from fresh water as fry (Subsection 3.2.3.2, Competition and Predation). Competition with natural-origin pink salmon fry for food and space from releases of hatchery-origin chum salmon fry likely occurs to a limited extent in fresh water, and to a greater extent in marine water, because of the substantial number of fry released from the Keta Creek chum salmon program (up to 5,000,000 fry), similarity in size between the hatchery-origin chum salmon fry and natural-origin pink salmon fry, and timing of hatchery-origin chum salmon fry releases that overlaps part of the outmigration period for natural-origin pink salmon fry (Table 15). Hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings are unlikely to compete with natural-origin pink salmon fry because of their larger size and associated food and space requirements.

In summary, considering all potential competition risks, the existing salmon and steelhead hatchery programs overall have a low negative competition effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 31), primarily because of mortality from competition in nearshore marine areas associated with releases of hatchery-origin chum salmon fry to the extent they overlap in time and space with natural-origin pink salmon fry before they migrate to the ocean (Subsection 3.2.3.2, Competition and Predation).

Alternative 1 - Competition: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions (Subsection 3.2.3.2, Competition and Predation), and would release up to 12,443,000 salmon and steelhead annually, including up to 5,000,000 chum salmon fry (Table 28). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 fall-run Chinook salmon, steelhead, and coho salmon juveniles would be released from the three new FRF hatchery programs (Table 28). The new FRF hatchery programs and associated release scenarios would not compete with natural-origin pink salmon because the species produced by those programs are not considered competitors for food and space with natural-origin pink salmon (Subsection 3.2.3.2, Competition and Predation). The risk of competition from hatchery-origin chum salmon and the similarly sized natural-origin pink salmon would be greatest in nearshore marine areas, where the fish may congregate after out-migrating from freshwater.

In summary, under Alternative 1, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a low negative competition effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 31), which would be the same as under existing conditions, primarily because of mortality from competition in nearshore marine areas associated with releases of hatchery-origin chum salmon fry, to the extent they overlap in time and space with natural-origin pink salmon fry before they migrate to the ocean (Subsection 3.2.3.2, Competition and Predation). There would be no change in releases of hatchery-origin chum salmon compared to existing conditions.

Alternative 2 - Competition: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would be same as under Alternative 1 (Table 28). Competition for food and space from those releases on natural-origin pink salmon fry would be the same as under existing conditions and Alternative 1 and would result primarily from competition between hatchery-origin chum salmon fry and natural-origin pink salmon fry in nearshore marine waters, where the fish may congregate after out-migrating from freshwater (Subsection 3.2.3.2, Competition and Predation).

In summary, under Alternative 2, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have low negative competition effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 31), which would be the same as under existing conditions and Alternative 1, primarily because of mortality from competition in nearshore marine areas associated with releases of hatchery-origin chum salmon fry, to the extent they overlap in time and space with natural-origin pink salmon fry before they migrate to the ocean (Subsection 3.2.3.2, Competition and Predation). There would be no change in releases of hatchery-origin chum salmon compared to existing conditions and Alternative 1.

Alternative 3 - Competition: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release up to 12,443,000 salmon and steelhead as under existing conditions, including up to 5,000,000 chum salmon fry, and the additional 1,550,000 salmon and steelhead juveniles produced by the new FRF hatchery programs under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all competition for food and space with natural-origin pink salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the salmon and steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin salmon and steelhead returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential competition risks, the elimination of the salmon and steelhead hatchery programs overall would have a low positive competition effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 31) because all mortality from competition for food and space with natural-origin pink salmon from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2, which would all have a low negative competition effect.

Alternative 4 - Competition: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release up to 6,996,500 fewer salmon and steelhead, including 2,500,000 fewer chum salmon fry (Table 28). Substantially fewer hatchery-origin fish would be released under Alternative 4, reducing competition for food and space between hatchery-origin chum salmon fry and natural-origin pink salmon fry in fresh water, and especially in nearshore marine water, compared to existing conditions, Alternative 1, and Alternative 2 (Subsection 3.2.3.2, Competition and Predation).

In summary, under Alternative 4, considering all potential competition risks, the salmon and steelhead hatchery programs overall would have a negligible negative competition effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 31), which would be less than under existing conditions, Alternative 1, and Alternative 2, primarily because the number of hatchery-origin chum salmon fry and associated mortality from competition for food and space in nearshore marine areas would be reduced. In comparison to Alternative 3 (low positive), competition under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for the hatchery-origin salmon and steelhead to compete with natural-origin pink salmon fry.

Predation – Hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings produced by hatchery programs in the Duwamish-Green River Basin pose direct and indirect predation risks to natural-origin pink salmon fry (Subsection 3.2.3.2, Competition and Predation) that may result in mortality of natural-origin pink salmon fry. Predation risks to natural-origin fish occur when the hatchery-origin fish are at least 50 percent larger and occur at the same time and place as natural-origin fish. Hatchery-origin fall-run Chinook salmon (especially yearlings) and steelhead yearlings are released during parts of the peak outmigration period of natural-origin pink salmon fry (Table 15). In contrast, hatchery-origin coho salmon yearlings are released about the same time as the peak out-migration of natural-origin pink salmon fry (Table 15), thus posing a greater predation risk to natural-origin pink salmon fry (Subsection 3.2.3.2, Competition and Predation). Hatchery-origin chum salmon fry are not predators of natural-origin pink salmon fry, which are similar in size (Table 15). In marine areas, predation on natural-origin pink salmon fry by larger hatchery-origin fall-run Chinook salmon, steelhead, and coho salmon yearlings occurs but is of limited duration because the yearlings likely disperse rapidly toward the ocean from river mouths and nearshore areas where natural-origin pink salmon fry initially congregate (Subsection 3.2.3.2, Competition and Predation).

In summary, considering all potential predation risks, the existing salmon and steelhead hatchery programs overall have a low negative predation effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 32), primarily because of mortality from predation in fresh water and marine water from larger hatchery-origin coho salmon yearlings, and to a lesser extent fall-run Chinook salmon (especially yearlings) and steelhead yearlings, on natural-origin pink salmon fry. The release timing of these hatchery-origin fish occurs at least during part of the peak out-migration period of natural-origin pink salmon fry.

Alternative 1 – Predation: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions, and a total of 3,113,000 yearlings (300,000 fall-run Chinook salmon, 133,000 steelhead, and 2,680,000 coho salmon yearlings) would be released (Subsection 3.2.3.2, Competition and Predation). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from the new FRF hatchery programs (Table 28). Without fish passage at Howard Hanson Dam, the new FRF coho salmon programs would release a total of 600,000 coho salmon yearlings and 350,000 steelhead yearlings below the dam, whereas with passage a total of 100,000 coho salmon yearlings and 70,000 steelhead yearlings would be released below the dam (Table 27). The new FRF hatchery programs would not produce fall-run Chinook yearlings and would not produce steelhead or coho salmon yearlings for release above the dam (Table 27). Under Alternative 1, the total number of hatchery-origin yearlings released would be 3,280,000 coho salmon and 483,000 steelhead without passage at the dam, or 2,780,000 coho and 203,000 steelhead with passage at the dam (Table 3). Compared to existing conditions under which there are no FRF hatchery programs, the releases of hatchery-origin yearlings from the new FRF hatchery programs under Alternative 1 would increase predation on natural-origin pink salmon, especially without passage, and primarily because of the larger number of coho salmon yearlings that would be released during the outmigration period of the smaller natural-origin pink salmon fry within the Duwamish-Green River Basin.

In summary, under Alternative 1, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a moderate negative predation effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 32), which would be greater than under existing conditions (low negative), primarily because of mortality from predation in fresh water and marine water associated with the coho salmon yearlings released from the new FRF coho salmon program (especially under the no fish passage scenario), which would not occur under existing conditions.

Alternative 2 – Predation: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would be same as under Alternative 1 (Table 28). Predation from those releases on natural-origin pink salmon would be the same as under Alternative 1, resulting primarily from predation by hatchery-origin coho salmon yearlings, and to a lesser extent fall-run Chinook salmon and steelhead yearlings, that are larger than natural-origin pink salmon fry when the hatchery-origin fish overlap with natural-origin pink salmon fry in time and space (Subsection 3.2.3.2, Competition and Predation). Predation from the two release scenarios from the new FRF hatchery programs (Table 27) on natural-origin pink salmon fry would be the same as under Alternative 1, whereby predation on natural-origin pink salmon fry would be greater under the scenario without fish passage, primarily because larger numbers of hatchery-origin coho salmon yearlings and steelhead yearlings would be released, which would increase predation on natural-origin pink salmon fry within the Duwamish-Green River Basin.

In summary, under Alternative 2, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have a moderate negative predation effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 32), which would be the same as under Alternative 1, but greater than under existing conditions (low negative), primarily because of mortality from predation in fresh water associated with coho salmon yearlings released from the new FRF coho salmon program (especially under the no fish passage scenario), which would not occur under existing conditions.

Alternative 3 – Predation: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release 3,113,000 fall-run Chinook salmon, steelhead, and coho salmon yearlings as under existing conditions. In addition, 100,000 to 600,000 coho salmon yearlings and 70,000 to 350,000 steelhead yearlings (depending on fish passage at Howard Hanson Dam) would not be produced by the new FRF hatchery programs as under Alternative 1 and Alternative 2 (Table 28). Therefore, all predation on natural-origin pink salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 3, considering all potential predation risks, the elimination of the salmon and steelhead programs overall would have a moderate positive predation effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 32) because all mortality from predation on natural-origin pink salmon from the hatchery programs would be eliminated, relative to Alternative 1 and Alternative 2 (which would both have a moderate negative predation effect), and existing conditions (which has a low negative predation effect).

Alternative 4 – Predation: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release 150,000 fewer hatchery-origin fall-run Chinook salmon yearlings, 1,340,000 fewer coho salmon yearlings, and 66,500 fewer steelhead yearlings than under existing conditions, and 50,000 to 300,000 fewer coho salmon yearlings and 35,000 to 175,000 fewer steelhead yearlings (depending on fish passage at Howard Hanson Dam) from the new FRF salmon programs (Table 3 and Table 28) than under Alternative 1 and Alternative 2. Under Alternative 4, a total of 150,000 hatchery-origin fall-run Chinook salmon yearlings, 1,390,000 to 1,640,000 coho salmon yearlings, and 116,500 to 241,500 steelhead yearlings would be released (depending on fish passage at the dam). Under Alternative 4, predation from these yearling releases on natural-origin pink salmon fry would be less than under Alternative 1 and Alternative 2, but similar to predation under existing conditions because a similar number of yearling salmon would be released that would prey on natural-origin pink salmon fry.

In summary, under Alternative 4, considering all potential predation risks, the salmon and steelhead hatchery programs overall would have low negative predation effect on natural-origin pink salmon in the Duwamish-Green River Basin (Table 32), which would be lower than under Alternative 1 and Alternative 2 (moderate negative), but the same as under existing conditions, primarily because of mortality from predation in fresh water and marine water by hatchery-origin coho salmon yearlings and release timing of these hatchery-origin fish that occurs during the peak out-migration period of natural-origin pink salmon fry. In comparison to Alternative 3 (moderate positive), predation under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for the hatchery-origin salmon and steelhead to prey on natural-origin pink salmon fry.

4.2.3 Facility Operations

Hatchery facility operations can affect fish habitat through withdrawal of water from streams, operation of instream structures (e.g., water intake structures, fish ladders, and weirs), and/or maintenance of instream structures that result in the removal of existing vegetation and potential temporary sedimentation along stream banks (Subsection 3.2.3.3, Facility Operations). Implementation of past (NMFS 1996, 1997) and current guidelines (NMFS 2011a) avoids or minimizes effects from structures; however, not all hatcheries meet these guidelines (Table 17). The Soos Creek Hatchery does not meet current NMFS water intake fish passage criteria, and the Soos Creek Hatchery and Keta Creek Complex do not meet current fish screening criteria (Table 17). The operators of these facilities intend to meet these guidelines given future funding. Weir operations and facility maintenance activities at the hatchery facilities are unlikely to impact fish passage or habitat in the Duwamish-Green River Basin. Effects of the existing hatchery programs on water quantity and water quality are described in Subsection 3.1, Water Quantity and Quality, and under the alternatives in Subsection 4.1, Water Quantity and Quality.

In summary, considering all potential facility operations risks, the existing salmon and steelhead hatchery programs overall have a low negative hatchery facilities effect on natural-origin salmon and steelhead under existing conditions (Table 33), primarily because not all of the facilities comply with current screening and passage criteria – one that does not comply with current water intake screening criteria and two that do not meet current fish passage criteria – resulting in some potential for the abundance and distribution of fish to be negatively affected, and effects from weir operations and instream maintenance activities on natural-origin salmon and steelhead migration that are not substantial.

Table 33. Comparative summary of facility operations effects on natural-origin salmon and steelhead under the alternatives.

Natural-origin Species	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
All Salmon and Steelhead	Low negative	Low negative	Low negative	Low positive	Low negative

Alternative 1: Under Alternative 1, water intake structures, instream structures, and their maintenance associated with the seven existing hatchery programs would continue to operate as under existing conditions (Subsection 3.2.3.3, Facility Operations), which would release up to 12,443,000 salmon and steelhead annually (Table 28). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from three new FRF hatchery programs (Table 28). Hatchery facility operations effects (e.g., from water intake structures, instream structures, and their maintenance) on natural-origin salmon and steelhead would be the same as under existing conditions, resulting primarily from effects on abundance and distribution of fish due to lack of

compliance with current criteria for water intake screening at two facilities (Soos Creek Hatchery and Keta Creek Complex) and for current fish passage criteria at one facility (Soos Creek Hatchery).

As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery programs associated with potential fish passage at Howard Hanson Dam. Although they are not yet constructed, the new FRF hatchery programs and associated release scenarios would not be expected to change hatchery facility risks to natural-origin salmon and steelhead in the Duwamish-Green River Basin because the intent is for the facilities to comply with current guidelines and compliance requirements (Muckleshoot Indian Tribe 2014a, 2014c, 2014d).

In summary, under Alternative 1, considering all potential hatchery facility operations risks, the salmon and steelhead hatchery programs overall would have a low negative hatchery facilities effect on natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 33), which would be the same as under existing conditions, primarily because the abundance and distribution of fish would be affected by two facilities that would not yet comply with current water intake screening criteria (Soos Creek Hatchery and Keta Creek Complex) and one facility would not meet current fish passage criteria (Soos Creek Hatchery).

Alternative 2: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would total 13,993,000 juveniles, which would be same as under Alternative 1 (Table 28). Hatchery facility operations effects (e.g., from water intake structures, instream structures, and their maintenance) to natural-origin salmon and steelhead would be the same as under Alternative 1, and would result primarily from effects on abundance and distribution of fish due lack of compliance with current criteria for water intake screening at two facilities (Soos Creek Hatchery and Keta Creek Complex) and for current fish passage at one facility (Soos Creek Hatchery).

In summary, under Alternative 2, considering all potential hatchery facility operations risks, the salmon and steelhead hatchery programs overall would have a low negative hatchery facilities effect on natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 33), which would be the same as under existing conditions and Alternative 1, primarily because the abundance and distribution of fish would be affected by two of the facilities would not comply with current water intake screening criteria (Soos Creek Hatchery and Keta Creek Complex) and one facility would not meet current fish passage criteria (Soos Creek Hatchery).

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release up to 12,443,000 salmon and steelhead as under existing conditions, and the additional 1,550,000 salmon and steelhead juveniles produced by the new FRF hatchery programs under Alternative 1 and Alternative 2 would not be released (Table 28). All structures would continue to be used, and hatchery facility operations effects (e.g., from water intake structures, instream structures, and their maintenance) on natural-origin salmon and steelhead associated with the ongoing and proposed new programs would be expected to be the same as under existing conditions, Alternative 1, and Alternative 2 because the facilities would likely continue to operate to produce fish for other hatchery programs.

In summary, under Alternative 3, considering all potential hatchery facility operations risks, the salmon and steelhead hatchery programs overall would have a low positive hatchery facilities effect on natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 33), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because the abundance and distribution of fish would be affected by two facilities that would not comply with current water intake screening criteria (Soos Creek Hatchery and Keta Creek Complex) and one facility that would not meet current fish passage criteria (Soos Creek Hatchery).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release up to 6,996,500 fewer hatchery-origin salmon and steelhead from ongoing and proposed new FRF hatchery programs than under existing conditions, Alternative 1, and Alternative 2 (Table 28). All structures would continue to be used, and hatchery facility operations effects (e.g., from water intake structures, instream structures, and their maintenance) on natural-origin salmon and steelhead associated with the ongoing and proposed new programs would be the same as under existing conditions, Alternative 1, Alternative 2, and Alternative 3.

In summary, under Alternative 4, considering all potential hatchery facility operations risks, the salmon and steelhead hatchery programs overall would have a low negative hatchery facilities effect on natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 33), which would be the same as under existing conditions, Alternative 1, Alternative 2, and Alternative 3, primarily because the abundance and distribution of fish would be affected by two facilities that would not comply with current water intake screening criteria (Soos Creek Hatchery and Keta Creek Complex) and one facility that would not meet current fish passage criteria (Soos Creek Hatchery).

4.2.4 Masking

Masking occurs when hatchery-origin fish mix with and are not identifiable from natural-origin fish, which may hamper estimation and monitoring of the abundance of hatchery-origin and natural-origin fish, and other factors such as the composition of hatchery-origin and natural-origin fish in natural spawning areas, straying, evaluations of hatchery performance, and contributions of hatchery-origin and natural-origin fish to fisheries (Subsection 3.2.3.4, Masking). To avoid this issue, most hatchery programs mark juveniles prior to their release using techniques such as clipping of adipose fins and/or insertion of coded-wire tags. Masking is particularly important for integrated hatchery programs because the intent of those programs is to produce hatchery-origin fish that are similar to and mix with their natural-origin counterparts. In contrast, the intent of isolated hatchery programs is for hatchery-origin fish to be dissimilar to and separate from natural-origin fish. There are two existing hatchery programs in the Duwamish-Green River Basin that are isolated programs (Subsection 3.2.3.4, Masking), and there is no masking of natural-origin salmon and steelhead abundance by these programs, because fish from the two programs are distinguishable from natural-origin fish. The remaining five existing programs are integrated hatchery programs. With the exception of hatchery-origin chum salmon, most of the releases from existing hatchery programs (84 percent) are marked prior to release and can be distinguished from natural-origin fish (Subsection 3.2.3.4, Masking). Although chum salmon juveniles in the Duwamish-Green River Basin are not mass-marked, the hatchery operators are considering marking the otoliths of these fish prior to release in the future (Muckleshoot Indian Tribe 2014b). There is no masking of natural-origin pink salmon abundance because there are no hatchery programs for pink salmon in the project area.

In summary, considering all potential masking risks, the existing salmon and steelhead hatchery programs overall have a negligible negative masking effect on natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 34), primarily because (with the exception of the chum salmon program) a large percentage (84 percent) of the releases from the hatchery programs are marked to allow for hatchery-origin fish to be accounted for in abundance estimates of natural-origin fish.

Table 34. Comparative summary of masking effects on natural-origin salmon and steelhead under the alternatives.

Natural-origin Species	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
All Salmon and Steelhead	Negligible negative	Negligible negative	Negligible negative	Negligible positive	Negligible negative

Alternative 1: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions, and would release up to 12,443,000 salmon and steelhead annually (Table 28). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from three new FRF (integrated) hatchery programs (Table 28). As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery programs associated with potential fish passage at Howard Hanson Dam. The three new FRF hatchery programs and associated release scenarios would not pose masking risks to natural-origin salmon and steelhead because juvenile fall-run Chinook salmon, steelhead, and coho salmon from the new FRF hatchery programs would be mass-marked prior to release.

In summary, under Alternative 1, considering all potential masking risks, the salmon and steelhead hatchery programs overall would have a negligible negative masking effect on natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 34), which would be the same as under existing conditions, primarily because most hatchery-origin fish would be mass-marked so they can be accounted for in abundance estimates of natural-origin fish, and there are plans for hatchery-origin chum salmon to be mass-marked.

Alternative 2: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would total 13,993,000 juveniles, which would be same as under Alternative 1 (Table 28). Masking the abundance of natural-origin salmon and steelhead would be the same as under Alternative 1, primarily because a large percentage of the releases from the hatchery programs would be mass-marked to allow for hatchery-origin fish to be accounted for in abundance estimates of natural-origin fish, and there are plans for hatchery-origin chum salmon to be mass-marked.

In summary, under Alternative 2, considering all potential masking risks, the salmon and steelhead hatchery programs overall would have a negligible negative masking effect on natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 34), which would be the same as under existing conditions and Alternative 1, primarily because most hatchery-origin fish would be mass-marked so they can be accounted for in abundance estimates of natural-origin fish, and there are plans for hatchery-origin chum salmon to be mass-marked.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release up to 12,443,000 salmon and steelhead as under existing conditions, and the additional 1,550,000 salmon and steelhead juveniles produced by the new FRF hatchery programs under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all masking of natural-origin salmon and steelhead associated with the ongoing and proposed new hatchery programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 3, considering all potential masking risks, the elimination of the salmon and steelhead programs overall would have a negligible positive masking effect on natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 34) because all masking on natural-origin salmon and steelhead from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which would all have a negligible negative masking effect).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release up to 6,996,500 fewer hatchery-origin salmon and steelhead from ongoing and proposed new FRF hatchery programs than under Alternative 1, Alternative 2, and existing conditions (Table 28). Although fewer fish would be produced under Alternative 4 compared to existing conditions, Alternative 1, and Alternative 2, masking of natural-origin salmon and steelhead would be the same as under existing conditions, Alternative 1 and Alternative 2, primarily because most hatchery-origin fish would be mass-marked so they can be accounted for in abundance estimates of natural-origin fish, and there are plans for hatchery-origin chum salmon to be mass-marked.

In summary, under Alternative 4, considering all potential masking risks, the salmon and steelhead hatchery programs overall would have a negligible negative effect on natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 34), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because most hatchery-origin fish would be accounted for in abundance estimates of natural-origin fish because they would be mass-marked, and there are plans for hatchery-origin chum salmon to be mass-marked. In comparison to Alternative 3 (negligible positive), masking under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for masking.

4.2.5 Incidental Fishing

Incidental fishing may impact natural-origin salmon and steelhead when fisheries (i.e., commercial, recreational, and tribal ceremonial and subsistence) targeting hatchery-origin fish harvest natural-origin fish (Subsection 3.2.3.5, Incidental Fishing). As summarized in Subsection 3.2.3.5, Incidental Fishing, effects from harvest on natural-origin fish from fisheries targeting hatchery-origin fish are described in the PS Harvest FEIS (NMFS 2004), as well as in ESA section 7 biological opinions and 4(d) Rule evaluations (e.g., NMFS 2015, 2016d). The socioeconomic effects of harvest are reviewed in this EIS in Subsection 3.5, Socioeconomics, and analyzed under the alternatives in Subsection 4.5, Socioeconomics.

Commercial (tribal and non-tribal) and recreational fisheries exist for Chinook salmon, summer-run steelhead, coho salmon, and chum salmon within the Duwamish-Green River Basin and adjacent marine catch areas (e.g., Catch Areas 10 and 10A), targeting hatchery-origin fish produced by the programs operating in the river basin. Tribal ceremonial and subsistence fisheries may catch natural-origin fish.

As described in Subsection 3.2.3.5, Incidental Fishing, the harvest of fish in Puget Sound is constrained so that it does not impede recovery of species listed under the ESA (including Chinook salmon and steelhead). There are currently no fisheries that specifically target natural-origin Chinook salmon. Similarly, there are no non-tribal commercial fisheries for steelhead in marine and freshwater areas. Terminal harvest rates of natural-origin winter-run steelhead in tribal and non-tribal fisheries are low, averaging 1.6 percent. Recent NMFS biological opinions (e.g., NMFS 2015, 2016d) found that impacts from salmon and steelhead harvest would not appreciably reduce the likelihood of survival and recovery of listed species. In addition, harvests of non-listed species are managed in consideration of the need to meet their escapement goals. Incidental harvest of coho salmon, chum salmon, and pink salmon occur but are not substantial (Subsection 3.2.3.5, Incidental Fishing). Most harvest of coho salmon and chum salmon is hatchery-origin fish. For example, recent average tribal net fishery harvests of hatchery-origin coho salmon in the Duwamish-Green River Basin have averaged 91 percent of the total coho salmon catch, and recent recreational harvests of hatchery-origin coho salmon have averaged 91 percent of the total coho salmon catch (Subsection 3.2.3.5, Incidental Fishing).

In summary, considering all potential incidental fishing risks, the existing salmon and steelhead hatchery programs overall have a negligible negative effect on the status of natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 35), primarily because, although the hatchery production leads to increased fishing, relatively few natural-origin fish are incidentally caught in fisheries targeting other species.

Table 35. Comparative summary of incidental fishing effects on natural-origin salmon and steelhead under the alternatives.

Natural-origin Species	**Existing Conditions**	**Alternative 1 (No Action)**	**Alternative 2 (Proposed Action)**	**Alternative 3 (Termination)**	**Alternative 4 (Reduced Production)**
All Salmon and Steelhead	Negligible negative	Negligible negative	Negligible negative	Negligible positive	Negligible negative

Alternative 1: Under Alternative 1, incidental fishing effects associated with the seven existing hatchery programs would be the same as under existing conditions (Subsection 3.2.3.5, Incidental Fishing), which would release up to 12,443,000 salmon and steelhead annually (Table 28). Under Alternative 1, in contrast to existing conditions, an additional 1,550,000 juveniles would be released from new FRF hatchery programs for fall-run Chinook salmon, late winter-run steelhead, and coho salmon (Table 28). These three hatchery programs would result in more returning adult Chinook salmon, steelhead, and coho salmon than under existing conditions, and mortalities from incidental fishing may increase, especially for natural-origin Chinook salmon and coho salmon catch in Puget Sound and in the river basin; however, the impacts would not be expected to increase substantially compared to existing conditions. This is primarily because relatively few natural-origin fish would be caught incidentally in fisheries targeting adults returning from the 10 hatchery programs, and fisheries would be planned such that NMFS could determine that the impacts from harvest would not appreciably reduce the likelihood of survival and recovery of listed salmon and steelhead in Puget Sound.

In summary, under Alternative 1, considering all potential incidental fishing effects, the salmon and steelhead hatchery programs overall would have a negligible negative effect on the status of natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 35), primarily because relatively few natural-origin fish would be caught incidentally in fisheries, and NMFS would ensure that the impacts of planned harvest would not appreciably reduce the likelihood of survival and recovery of listed salmon and steelhead in Puget Sound.

Alternative 2: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would total 13,993,000 juveniles, which would be same as under Alternative 1 (Table 28). Incidental fishing effects would be the same as under Alternative 1, because the numbers of fish available for harvest would be the same.

In summary, under Alternative 2, considering all potential incidental fishing effects, the salmon and steelhead hatchery programs overall would have a negligible negative effect on the status of natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 35), which would be the same as under Alternative 1, primarily because relatively few natural-origin fish would be caught incidentally in fisheries, and NMFS would ensure that the impacts of planned harvest would not appreciably reduce the likelihood of survival and recovery of listed salmon and steelhead in Puget Sound.

Alternative 3: Under Alternative 3, all 10 of the hatchery programs in the Duwamish-Green River Basin would be terminated and would not release up to 12,443,000 salmon and steelhead as under existing conditions, and the additional 1,550,000 salmon and steelhead juveniles produced by the new FRF hatchery programs under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all mortalities associated with incidental fishing would be eliminated relative to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 3, considering all potential incidental fishing risks, the salmon and steelhead hatchery programs overall would have a negligible positive effect on the status of natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 35) because all mortality associated with incidental fishing from the hatchery programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2 (which would all have negligible negative incidental fishing effects).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release up to 6,996,500 fewer salmon and steelhead from ongoing and proposed new FRF programs than under existing conditions, Alternative 1, Alternative 2 (Table 28). Because of the substantial reduction in the number of salmon and steelhead released, fewer hatchery-origin salmon and steelhead adults would be available for harvest; thus, there would be less mortality on natural-origin salmon and steelhead from incidental fishing associated with the hatchery programs.

In summary, under Alternative 4, considering all potential incidental fishing risks, the salmon and steelhead hatchery programs overall would have a negligible negative effect on the status of natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 35), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because relatively few natural-origin fish would be caught incidentally in fisheries, and NMFS would ensure that the impacts of planned harvest would not appreciably reduce the likelihood of survival and recovery of listed salmon and steelhead in Puget Sound. In comparison to Alternative 3 (negligible positive), mortality from incidental fishing under Alternative 4 would be greater because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for the hatchery programs to lead to incidental fishing on natural-origin salmon and steelhead.

4.2.6 Disease

Fish disease pathogens can be present in hatchery-origin and natural-origin salmon and steelhead, and interactions between these groups in the natural environment can result in transmission of pathogens from fish that carry diseases (Subsection 3.2.3.6, Disease). Hatchery-origin fish may be at increased risk of carrying fish disease pathogens because the fish are reared at relatively high densities in hatchery facilities, which can increase stress to the fish and lead to spread of diseases. In turn, hatchery-origin salmon and steelhead released into the environment may pose an increased risk of transferring diseases to natural-origin salmon and steelhead. However, hatchery programs in the Duwamish-Green River Basin are operated in compliance with applicable fish health guidelines, and monitoring for fish diseases occurs monthly, which promote release of hatchery-origin fish in a healthy condition.

In summary, considering all potential disease risks, the existing salmon and steelhead hatchery programs overall have a negligible negative effect on transfer of diseases to natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 36), primarily because the programs are operated in compliance with all fish health protection guidelines and monitoring.

Table 36. Comparative summary of disease effects on natural-origin salmon and steelhead under the alternatives.

Natural-origin Species	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
All Salmon and Steelhead	Negligible negative	Negligible negative	Negligible negative	Negligible positive	Negligible negative

Alternative 1: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions and would release up to 12,443,000 salmon and steelhead annually (Table 28). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 fall-run Chinook salmon, steelhead, and coho salmon juveniles would be released from three new FRF hatchery programs (Table 28). As shown in Table 26, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery programs associated with potential fish passage at Howard Hanson Dam. The fish released from the new FRF hatchery programs would have the potential to increase the risk of disease transfers to natural-origin fish relative to existing conditions because of the additional production and release locations in the upper river, including releases above the dam if fish passage exists. However, the new FRF hatchery programs and associated release scenarios would not be expected to substantially change the likelihood of disease transfer to natural-origin salmon and

steelhead in the Duwamish-Green River Basin overall because all of the programs would be operated in compliance with all fish health protection guidelines and monitoring.

In summary, under Alternative 1, considering all potential disease risks, the salmon and steelhead hatchery programs overall would have a negligible negative effect on the transfer of diseases to natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 36), which would be the same as under existing conditions, primarily because all hatchery programs, including the proposed FRF hatchery programs, would be required to comply with all fish health protection guidelines and monitoring.

Alternative 2: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would total 13,993,000 juveniles, which would be same as under Alternative 1 (Table 28). Transfer of diseases to natural-origin salmon and steelhead would be the same as under Alternative 1, primarily because all hatchery programs would be required to comply with all fish health protection guidelines and monitoring.

In summary, under Alternative 2, considering all potential disease risks, the salmon and steelhead hatchery programs overall would have a negligible negative effect on the transfer of diseases to natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 36), which would be the same as under existing conditions and Alternative 1, primarily because all the programs would be operated in compliance with all fish health protection guidelines and monitoring.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and would not release 12,443,000 salmon and steelhead as under existing conditions, and the additional 1,550,000 salmon and steelhead juveniles produced by the new FRF hatchery programs under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all transfer of diseases to natural-origin salmon and steelhead associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 3, considering all potential disease risks, the elimination of the salmon and steelhead programs overall would have a negligible positive effect on the transfer of diseases to natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 36) because all transfer of diseases to natural-origin salmon and steelhead from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2.

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release up to 6,996,500 fewer hatchery-origin salmon and steelhead from ongoing and proposed new FRF hatchery programs than under existing conditions, Alternative 1, and Alternative 2 (Table 28). Although fewer fish would be produced under Alternative 4 compared to Alternative 1 and Alternative 2, transfer of diseases to natural-origin salmon and steelhead would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because all hatchery programs would be required to comply with all fish health protection guidelines and monitoring.

In summary, under Alternative 4, considering all potential disease effects, the salmon and steelhead hatchery programs overall would have a negligible negative effect on the transfer of diseases to natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 36), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because all hatchery programs would be required to comply with all fish health protection guidelines and monitoring. In comparison to Alternative 3 (negligible positive), transfer of diseases under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for transfer of diseases to natural-origin salmon and steelhead.

4.2.7 Population Viability Benefits

Hatchery programs can have positive and negative effects on natural-origin salmon and steelhead (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). Mechanisms associated with negative effects are discussed elsewhere in Subsection 3.2, Salmon and Steelhead (especially Subsection 3.2.3.1, Genetics, and Subsection 3.2.3.2, Competition and Predation). This subsection reviews potential positive effects from hatchery programs in terms of their contribution to the viability of natural-origin populations, which can also contribute to the viability of listed species. One type of hatchery program (integrated programs) may benefit the viability of natural-origin populations because these programs produce fish that are intended to be similar to and integrated with the natural-origin population (Subsection 3.2.3.7, Population Viability Benefits). In contrast, isolated hatchery programs do not provide population viability benefits because fish from those programs are intended to be different from natural-origin populations (e.g., genetically, ecologically) to support harvest-oriented management objectives (Subsection 4.2.1, Genetics). Of the 10 existing and proposed salmon and steelhead hatchery programs in the Duwamish-Green River Basin, 8 would be operated as integrated programs and are reviewed in this subsection, and 2 would be operated as isolated programs (Table 3). This subsection reviews the population viability benefits from integrated hatchery programs under the alternatives by species, considering the following four population viability parameters (termed VSP parameters): abundance, diversity, spatial structure, and productivity (Subsection 3.2.3.7, Population Viability Benefits). Population viability benefits are not reviewed for natural-origin pink salmon in this EIS because there are no hatchery programs for pink salmon in the project area.

4.2.7.1 Chinook Salmon

There is one integrated fall-run Chinook salmon hatchery program in the Duwamish-Green River Basin under existing conditions, and it produces fish that are listed under the ESA (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). Due to the substantial size of this Soos Creek fall-run Chinook salmon hatchery program (4,200,000 subyearlings and 300,000 yearlings) (Table 3) and the low abundance of the natural-origin fall-run Chinook salmon population (897 fish), the hatchery program provides an important contribution to the total abundance of listed fall-run Chinook salmon in the river basin (average 2,168 spawners from 2010 to 2014; Subsection 3.2.3.7, Population Viability Benefits). Thus the hatchery program contributes substantially (1,271 fish annually) to the existing natural spawning population, uses natural-origin broodstock consistent with diversity present in the river basin, and bolsters use of available habitat by spawners in the system (Subsection 3.2.3.7, Population Viability Benefits). However, the contribution of the integrated hatchery program to the productivity of natural-origin fall-run Chinook salmon is unknown. The total abundance under existing conditions is well below the minimum viable abundance target for Chinook salmon in the Duwamish-Green River Basin is 17,000 fish (Ford 2011).

In summary, considering all potential population viability parameters, the existing Soos Creek fall-run Chinook salmon hatchery program has a moderate positive population viability benefit to natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 37), primarily because fish from the program help increase overall abundance and have a similar level of genetic diversity as the natural-origin population. Natural spawning by hatchery-origin fall-run Chinook salmon under existing conditions may bolster use of available habitat, thereby also contributing to spatial structure.

Table 37. Comparative summary of population viability benefits to natural-origin salmon and steelhead under the alternatives.

Natural-origin Species	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Fall-run Chinook Salmon	Moderate positive	Moderate positive	Moderate positive	Moderate negative	Low positive
Steelhead	Negligible positive	Low positive	Low positive	Low negative	Negligible positive
Coho Salmon	Moderate positive	Moderate positive	Moderate positive	Moderate negative	Low positive
Chum Salmon	Negligible positive	Negligible positive	Negligible positive	Negligible negative	Negligible positive

Alternative 1: Under Alternative 1, the Soos Creek fall-run Chinook salmon hatchery program would continue to operate as an integrated program, fish from this program would be genetically similar to natural-origin fall-run Chinook salmon in the Green River, and the number of juveniles released would continue to be substantial. Also under Alternative 1, in contrast to existing conditions, an additional 600,000 fall-run Chinook salmon juveniles would be produced from the new integrated FRF fall-run Chinook salmon program, which would increase the total number of juveniles released by 13 percent to 5,100,000, compared to 4,500,000 under existing conditions (Table 28). As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery program, associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as subyearlings below the dam with no passage, or 17 percent released as subyearlings below the dam and 83 percent released as fry above the dam with passage). With no fish passage at the dam, the release of 600,000 fall-run Chinook subyearlings below the dam would potentially produce 2,466 adults pre-harvest (assuming a survival rate of 0.41 percent), whereas with fish passage at the dam, the below-dam release of 100,000 subyearlings would potentially produce 411 adults pre-harvest (assuming a survival rate of 0.41 percent) and the above-dam release of 500,000 fry would potentially produce 205 adults pre-harvest (assuming a survival rate of 0.04 percent) (Holly Coccoli, Muckleshoot Indian Tribe, email sent to Tim Tynan, Fish Biologist, NMFS, August 12, 2016, regarding projected returns from FRF releases). Population viability benefits associated with the two release scenarios (Table 27) from this new FRF hatchery program on the natural-origin fall-run Chinook salmon population would be similar, except that because of higher survival rates from subyearling releases, a larger contribution to abundance would be expected from increased subyearling releases that would occur without fish passage at the dam, whereas with passage at the dam, returns of hatchery-origin adults from fry releases

would be expected to spawn above the dam and colonize habitat that has not been used by fall-run Chinook salmon since construction of the dam, which would contribute to spatial structure.

Considering overall population viability benefits from the two integrated fall-run Chinook salmon programs to natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin, the increase in Chinook salmon hatchery production from the new FRF hatchery program by 13 percent compared to existing conditions (Table 28) would marginally increase the potential population viability benefit because of increased abundance, and potentially spatial structure if hatchery-origin fish return to use habitat above the dam that has not been used by fall-run Chinook salmon since the dam was constructed.

In summary, under Alternative 1, considering all potential population viability parameters, although the increased production associated with the new integrated FRF fall-run Chinook salmon program would marginally increase population viability benefits, the two programs overall would have a moderate positive population viability benefit to natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 37), which is the same as under existing conditions, primarily because the programs would help increase overall abundance and have a similar level of genetic diversity as the natural-origin fall-run Chinook salmon population. Natural spawning by hatchery-origin fall-run Chinook salmon would bolster use of available habitat, and potentially bolster spatial structure if hatchery-origin fish return to use habitat above Howard Hanson Dam that has not been used by fall-run Chinook salmon since construction of the dam.

Alternative 2: Under Alternative 2, the integrated Soos Creek fall-run Chinook salmon program and new integrated FRF fall-run Chinook salmon hatchery program would operate as under Alternative 1. Releases of fall-run Chinook salmon from the two hatchery programs would be the same as under Alternative 1 (Table 28). Population viability benefits to natural-origin fall-run Chinook salmon associated with each of the two release scenarios for the new FRF fall-run Chinook program (Table 27) would be the same as under Alternative 1.

In summary, under Alternative 2, considering all potential population viability parameters, the fall-run Chinook salmon programs overall would have a moderate positive population viability benefit to natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 37), which would be the same as under existing conditions and Alternative 1, primarily because the programs would help increase overall abundance and have a similar level of genetic diversity as the natural-origin fall-run Chinook salmon population. Natural spawning by hatchery-origin fall-run Chinook salmon would bolster use of available habitat, and potentially contribute to spatial structure if hatchery-origin fish return to and are able to use habitat above Howard Hanson Dam.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and the integrated Soos Creek fall-run Chinook salmon program would not release 4,500,000 juveniles as under existing conditions, Alternative 1, and Alternative 2, and the additional 600,000 juveniles would not be produced by the new integrated FRF fall-run Chinook salmon program as under Alternative 1 and Alternative 2 (Table 28). Therefore, all population viability benefits to natural-origin fall-run Chinook salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the fall-run Chinook salmon from previous hatchery releases in the river basin have returned, there would be no hatchery-origin fall-run Chinook salmon returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential population viability parameters, the elimination of the salmon and steelhead programs overall would have a moderate negative population viability benefit to natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin (Table 37) because all population viability benefits to natural-origin fall-run Chinook salmon from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which would all have a moderate positive population viability benefit).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the integrated Soos Creek fall-run Chinook salmon hatchery program and the new integrated FRF fall-run Chinook salmon hatchery program would release 1,950,000 fewer hatchery-origin fall-run Chinook salmon juveniles than under existing conditions, and 2,550,000 fewer hatchery-origin fall-run Chinook salmon juveniles than under Alternative 1 and Alternative 2 (Table 28). Because of this substantial reduction in the number of fall-run Chinook salmon released, correspondingly fewer hatchery-origin fall-run Chinook salmon adults would return to the river basin; thus, the potential population viability benefits from the hatchery programs to the abundance, diversity, and spatial structure of natural-origin fall-run Chinook salmon would be reduced compared to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 4, considering all potential population viability parameters, the two integrated fall-run Chinook salmon hatchery programs overall would have a low positive population viability benefit to natural-origin fall-run Chinook salmon in the Duwamish-Green River Basin

(Table 37), which would be lower than under existing conditions, Alternative 1, and Alternative 2 (moderate positive), primarily because substantially fewer fall-run Chinook salmon would be released, resulting in fewer adults returning to the river basin, reducing the population viability benefits in terms of abundance, diversity, and spatial structure. Relative to Alternative 3 (moderate negative), population viability benefits under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for population viability benefits to natural-origin fall-run Chinook salmon.

4.2.7.2 Steelhead

There is one integrated steelhead hatchery program in the Duwamish-Green River Basin under existing conditions, and it produces fish that are listed under the ESA (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). Although of limited size (the program releases up to 33,000 yearlings annually) (Table 3), this integrated Green River late winter-run steelhead hatchery program may provide an important contribution to the total abundance of listed winter-run steelhead in the river basin. At this release level, assuming a smolt-to-adult survival rate of 0.5 to 1 percent, returns from the hatchery program would be 115 to 330 adults (Subsection 3.2.3.7, Population Viability Benefits). This abundance contributes to the recent 5-year mean spawner escapement of 552 (NWFSC 2015), but is well below the minimum viable abundance target of 9,884 fish (Hard et al. 2015). The hatchery program uses natural-origin broodstock that is consistent with diversity present in the river basin, likely contributes to the existing listed natural spawning population, and bolsters use of available habitat by spawners in the system (Subsection 3.2.3.7, Population Viability Benefits). However, the contribution of the integrated hatchery program to the productivity of natural-origin winter-run steelhead is unknown.

In summary, considering all potential population viability parameters, the existing Green River late winter-run steelhead hatchery program has a negligible positive population viability benefit on natural-origin steelhead in the Duwamish-Green River Basin (Table 37), primarily because, although fish from the program have a similar level of genetic diversity as the natural-origin population, the program likely helps increase overall abundance, and natural spawning by hatchery-origin winter-run steelhead under existing conditions may bolster use of available habitat and potentially spatial structure, the contribution of the program is limited by its small size.

Alternative 1: Under Alternative 1, the integrated Green River late winter-run steelhead program would continue to operate as under existing conditions, and population viability benefits from the program to the diversity, abundance, and spatial structure of natural-origin winter-run steelhead in the

Duwamish-Green River Basin would be the same as under existing conditions. Also under Alternative 1, in contrast to existing conditions, an additional 350,000 late winter-run steelhead juveniles would be released from the new FRF integrated late winter-run steelhead program. Fish from this program have been proposed for listing as part of the listed Puget Sound Steelhead DPS (81 Fed. Reg. 72759, October 21, 2016). This program would increase the total number of steelhead juveniles released under Alternative 1 from integrated programs substantially to 383,000 fish, compared to 33,000 under existing conditions (Table 3, Table 28). For at least the early stages of the new FRF late winter-run steelhead program, broodstock would probably be obtained from returns of hatchery-origin fish from the Green River late winter-run steelhead hatchery program.

Although population viability benefits from the new FRF late winter-run steelhead program would be expected to be similar to the existing late winter-run steelhead hatchery program, the release of an additional 350,000 hatchery-origin winter-run steelhead would increase the potential population viability benefits to abundance, diversity, and spatial structure. As shown in Table 27, there would be two different scenarios for releases of hatchery-origin late winter-run steelhead from the new FRF late winter-run steelhead program that would be associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as yearlings below the dam with no passage, or 20 percent released as yearlings below the dam and 80 percent released as fry above the dam with passage). With no fish passage at the dam, the release of 350,000 steelhead smolts below the dam would potentially produce 1,648 adults pre-harvest (assuming a survival rate of 0.47 percent), and with fish passage at the dam, the below-dam release of 70,000 steelhead would potentially produce 330 adults pre-harvest (assuming a survival rate of 0.47 percent) and the above-dam release of 280,000 steelhead fry would potentially produce 132 adults pre-harvest (assuming a survival rate or 0.047 percent) (Holly Coccoli, Muckleshoot Indian Tribe, email sent to Tim Tynan, Fish Biologist, NMFS, August 12, 2016, regarding estimated survival rates for FRF releases). Population viability benefits associated with the two release scenarios (Table 27) from this new FRF hatchery program on the natural-origin winter-run steelhead population would be similar, except that because of higher smolt-to-adult survival rates from smolt releases, a larger contribution to abundance would be expected from increased smolt releases that would occur without fish passage at the dam, whereas with passage at the dam, returns of hatchery-origin adults from fry and smolt releases would be expected to spawn above the dam and colonize habitat that has not been used by winter-run steelhead since construction of the dam, which would contribute to spatial structure.

In summary, under Alternative 1, considering all potential population viability parameters, the two integrated winter-run steelhead hatchery programs overall would have a low positive population viability benefit on natural-origin winter-run steelhead in the Duwamish-Green River Basin (Table 37), which would be higher than under existing conditions (negligible positive), primarily because of the new FRF winter-run steelhead program and its additional potential to benefit the abundance, diversity, and spatial structure of natural-origin winter-run steelhead associated with the substantial number of releases from the programs (totaling 383,000 juveniles) and release locations in the upper river basin under the fish passage scenarios.

Alternative 2: Under Alternative 2, the integrated Green River late winter-run steelhead program and new integrated FRF winter-run steelhead hatchery program would operate as under Alternative 1. Releases of steelhead from the two hatchery programs would be the same as under Alternative 1 (Table 28). Population viability benefits to natural-origin winter-run steelhead associated with each of the two release scenarios for the new FRF winter-run steelhead program (Table 27) would be the same as under Alternative 1.

In summary, under Alternative 2, considering all potential population viability parameters, the fall-run Chinook salmon programs overall would have a low positive population viability benefit effect to natural-origin winter-run steelhead in the Duwamish-Green River Basin (Table 37), which would be the same as under Alternative 1, but greater than under existing conditions (negligible positive), primarily because the programs would help increase overall abundance and have a similar level of genetic diversity as the natural-origin winter-run steelhead population. Natural spawning by hatchery-origin winter-run steelhead would bolster use of available habitat and potentially contribute to spatial structure if hatchery-origin fish return to and are able to use habitat above the dam.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and the Green River late winter-run program would not release 33,000 yearlings as under existing conditions, Alternative 1, and Alternative 2, and the additional 350,000 juveniles would not be produced by the new FRF late winter-run steelhead program as under Alternative 1 and Alternative 2 (Table 28). Therefore, all population viability benefits to natural-origin winter-run steelhead associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the winter-run steelhead from previous hatchery releases in the river basin have returned, there would be no hatchery-origin late winter-run returning to or spawning in the river basin that were produced by hatcher programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential population viability parameters, the elimination of the salmon and steelhead programs overall would have a low negative population viability benefit on natural-origin winter-run steelhead in the Duwamish-Green River Basin (Table 37), because all population viability benefits to natural-origin winter-run steelhead from the hatchery programs would be eliminated, relative to Alternative 1 and Alternative 2 (which would both have a low positive population viability benefit), and existing conditions (which has a negligible positive population viability benefit).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the integrated Green River late winter-run steelhead hatchery program and the new integrated FRF late winter-run steelhead hatchery program would release 158,500 more hatchery-origin late winter-run steelhead juveniles than under existing conditions, and 191,500 fewer hatchery-origin late winter-run steelhead juveniles than under Alternative 1 and Alternative 2 (Table 28). Because of this substantial reduction in the number of late winter-run steelhead released, correspondingly fewer hatchery-origin late winter-run steelhead adults would return to the river basin (58 to 115 fewer adults from the Green River late winter-run steelhead hatchery program, and 231 to 824 fewer adults from the FRF late winter-run steelhead hatchery program, depending on fish passage scenario); thus, the population viability benefits from the hatchery programs to the abundance, diversity, and spatial structure of natural-origin winter-run steelhead would be reduced compared to Alternative 1 and Alternative 2, but similar to existing conditions.

In summary, under Alternative 4, considering all potential population viability parameters, the two integrated winter-run steelhead hatchery programs overall would have a negligible positive population viability benefit to natural-origin winter-run steelhead in the Duwamish-Green River Basin (Table 35), which would be lower than under Alternative 1 and Alternative 2 (low positive), but the same as under existing conditions, primarily because substantially fewer late winter-run steelhead would be released, resulting in fewer adults returning to the river basin to contribute to abundance, diversity, and spatial structure, compared to Alternative 1 and Alternative 2. Relative to Alternative 3 (low negative), population viability benefits under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for population viability benefits to natural-origin winter-run steelhead.

4.2.7.3 Coho Salmon

Puget Sound coho salmon are not listed under the ESA but are a species of concern. In addition, abundant returns of hatchery-origin coho salmon represent a substantial portion of the remaining genetic resources in the ESU (Subsection 3.2.3.7, Population Viability Benefits). There are two integrated coho salmon programs in the Duwamish-Green River Basin under existing conditions (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). Together, these two programs (Soos Creek and Keta Creek programs) produce up to 2,800,000 coho salmon juveniles annually (including 2,680,000 yearling smolts and 120,000 fry) (Table 3), and although estimates of spawning escapements are not available, the substantial combined size of the programs likely makes an important contribution to the total abundance of coho salmon in the river basin. The hatchery programs use natural-origin broodstock, likely contribute to the existing natural spawning population, and bolster use of available habitat by coho salmon spawners in the basin (Subsection 3.2.3.7, Population Viability Benefits). The contribution of the integrated hatchery programs to the productivity of natural-origin coho salmon is unknown.

In summary, considering all potential population viability parameters, the two existing integrated coho salmon hatchery programs have a moderate positive population viability benefit on natural-origin coho salmon in the Duwamish-Green River Basin (Table 37), primarily because the combined size of the programs is substantial, fish from the programs help increase overall abundance, and fish from the programs have a similar level of genetic diversity as the natural-origin population. Natural spawning by hatchery-origin coho salmon under existing conditions may bolster use of available habitat, thereby also contributing to spatial structure.

Alternative 1: Under Alternative 1, the integrated coho salmon programs would continue to operate as under existing conditions, and population viability benefits from the programs to the diversity, abundance, and spatial structure of natural-origin coho salmon in the Duwamish-Green River Basin would be the same as under existing conditions. Also under Alternative 1, in contrast to existing conditions, an additional 600,000 coho salmon juveniles would be released from the new FRF integrated coho salmon program, which would increase the total number of juveniles released from integrated hatchery programs by 21 percent to 3,400,000, compared to 2,800,000 under existing conditions (Table 3, Table 28).

Although population viability benefits from the new FRF coho salmon program would be expected to be similar to the existing integrated coho salmon hatchery programs, the release of an additional 600,000 hatchery-origin coho salmon would increase the potential population viability benefits to diversity, abundance, and spatial structure. As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery program associated with potential fish passage at Howard Hanson Dam (i.e., 100 percent released as yearlings below the dam with no passage, or 17 percent released as yearlings below the dam and 83 percent released as fry above the dam with passage). Under Alternative 1, the total number of hatchery-origin coho salmon juveniles released below the dam from integrated programs would be 3,280,000 yearlings and 120,000 fry, without passage at the dam, or 2,780,000 yearlings and 120,000 fry below the dam and 500,000 fry above the dam with fish passage (Table 3). Population viability benefits associated with the two release scenarios (Table 27) from the new FRF coho salmon program on the natural-origin coho salmon population would be similar, except that because of higher smolt-to-adult survival rates from smolt releases, a larger contribution to abundance would be expected from increased smolt releases that would occur without fish passage at the dam, whereas with passage at the dam, returns of hatchery-origin adults from fry releases would be expected to spawn above the dam and colonize habitat that has not been used by coho salmon since construction of the dam, which would contribute to spatial structure.

In summary, under Alternative 1, considering all potential population viability parameters, although the increased production associated with the new integrated FRF coho salmon program (21 percent) would marginally increase population viability benefits, the three integrated programs overall would have a moderate positive population viability benefit on natural-origin coho salmon in the Duwamish-Green River Basin (Table 37), which would be the same as under existing conditions, primarily because the programs would help increase overall abundance and have a similar level of genetic diversity as the natural-origin coho salmon population. Natural spawning by hatchery-origin coho salmon would bolster use of available habitat and potentially contribute to spatial structure if hatchery-origin fish return to and are able use habitat above the dam.

Alternative 2: Under Alternative 2, the integrated Soos Creek, Keta Creek, and new integrated FRF coho salmon hatchery programs would operate as under Alternative 1. Releases of coho salmon from the three hatchery programs would be the same as under Alternative 1 (Table 28). Population viability benefits to natural-origin coho salmon associated with each of the two release scenarios for the new FRF coho salmon program (Table 27) would be the same as under Alternative 1.

In summary, under Alternative 2, considering all potential population viability parameters, the coho salmon programs overall would have a moderate positive population viability benefit effect to natural-origin coho salmon in the Duwamish-Green River Basin (Table 37), which would be the same as under existing conditions and Alternative 1, primarily because the programs would help increase overall abundance and have a similar level of genetic diversity as the natural-origin coho salmon population. Natural spawning by hatchery-origin coho salmon would bolster use of available habitat, and potentially contribute to spatial structure if hatchery-origin fish return to and are able to use habitat above the dam.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and the integrated Soos Creek and Keta Creek coho salmon programs would not release 2,800,000 juveniles as under existing conditions, Alternative 1, and Alternative 2, and the additional 600,000 juveniles would not be produced by the new FRF coho salmon program as under Alternative 1 and Alternative 2 (Table 28). Therefore, all population viability benefits to natural-origin coho salmon associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the coho salmon from previous hatchery releases in the river basin have returned, there would be no hatchery-origin coho salmon returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential population viability parameters, the elimination of the salmon and steelhead programs overall would have a moderate negative population viability benefit to natural-origin coho salmon in the Duwamish-Green River Basin (Table 37), because all population viability benefits to natural-origin coho salmon from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which would all have a moderate positive population viability benefit).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the integrated Soos Creek and Keta Creek coho salmon hatchery programs and the new integrated FRF coho salmon hatchery program would release a total of 1,100,000 fewer hatchery-origin coho salmon than under existing conditions and 2,300,000 fewer hatchery-origin coho salmon juveniles than under Alternative 1 and Alternative 2 (Table 3, Table 28). Because of this substantial reduction in the number of coho salmon released, correspondingly fewer hatchery-origin coho salmon adults would return to the river basin; thus, the population viability benefits from the hatchery programs to the abundance, diversity, and spatial structure of natural-origin coho salmon would be reduced.

In summary, under Alternative 4, considering all potential population viability parameters, the three integrated coho salmon hatchery programs overall would have a low positive population viability benefit to natural-origin coho salmon in the Duwamish-Green River Basin (Table 37), which would be lower than under existing conditions, Alternative 1, and Alternative 2 (moderate positive), primarily because substantially fewer coho salmon would be released, resulting in fewer adults returning to the river basin, reducing the population viability benefits in terms of abundance, diversity, and spatial structure. Relative to Alternative 3 (moderate negative), population viability benefits under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for population viability benefits to natural-origin coho salmon.

4.2.7.4 Chum Salmon

The most recent NMFS review of the status of fall-run chum salmon in Puget Sound determined that the chum salmon ESU is generally healthy and did not warrant listing under the ESA (Subsection 3.2.3.7, Population Viability Benefits). There is one integrated chum salmon hatchery program in the Duwamish-Green River Basin under existing conditions (Subsection 3.2.2.3, Salmon and Steelhead Hatchery Programs in the Duwamish-Green River Basin). Although estimates of spawning escapements are not available, due to the substantial size of this Keta Creek chum salmon hatchery program (5,000,000 fry) (Table 3), it is likely that the hatchery program contributes to the existing natural spawning population. In addition, the program uses natural-origin broodstock consistent with diversity present in the river basin, and may bolster use of available habitat by spawners in the basin (Subsection 3.2.3.7, Population Viability Benefits). Therefore, the hatchery program has the potential to provide abundance, diversity, and spatial structure benefits to the natural-origin chum salmon population. The contribution of the integrated hatchery program to the productivity of natural-origin chum salmon is unknown.

In summary, considering all potential population viability parameters, the existing chum salmon hatchery program has a negligible positive population viability benefit on natural-origin chum salmon in the Duwamish-Green River Basin (Table 37), primarily because, although fish from the program have a similar level of genetic diversity as the natural-origin population, likely contribute to overall abundance, and may bolster use of available habitat and potentially spatial structure, the viability benefit from the program is limited because the natural-origin chum salmon population is generally healthy.

Alternative 1: Under Alternative 1, the integrated chum salmon program would continue to operate as under existing conditions, and population viability benefits from the program to the diversity, abundance, and spatial structure of natural-origin chum salmon in the Duwamish-Green River Basin would be the same as under existing conditions, and the existing Keta Creek fall-run chum salmon program would continue to produce 5,000,000 fry.

In summary, under Alternative 1, considering all potential population viability parameters, the integrated chum salmon program overall would have a negligible positive population viability benefit on natural-origin chum salmon in the Duwamish-Green River Basin (Table 37), which would be the same as under existing conditions, primarily because all aspects of the program would be the same as under existing conditions.

Alternative 2: Under Alternative 2, the integrated chum salmon program would continue to operate as under existing conditions and Alternative 1, and population viability benefits from the programs to the diversity, abundance, and spatial structure of natural-origin chum salmon in the Duwamish-Green River Basin would be the same as under existing conditions and Alternative 1, and the existing Keta Creek fall-run chum salmon program would continue to produce 5,000,000 fry.

In summary, under Alternative 2, considering all potential population viability parameters, the integrated chum salmon program overall would have a negligible positive population viability benefit on natural-origin chum salmon in the Duwamish-Green River Basin (Table 37), which would be the same as under existing conditions and Alternative 1, primarily because all aspects of the program would be the same as under existing conditions and Alternative 1.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated, and the chum salmon program would not release 5,000,000 fry as under existing conditions, Alternative 1, and Alternative 2 (Table 28). Therefore, all population viability benefits to natural-origin chum salmon associated with the ongoing program would be eliminated relative to existing conditions, Alternative 1, and Alternative 2. Over time, once all of the chum salmon from previous hatchery releases in the river basin have returned, there would be no hatchery-origin chum salmon returning to or spawning in the river basin that were produced by hatchery programs in the Duwamish-Green River Basin.

In summary, under Alternative 3, considering all potential population viability parameters, the elimination of the salmon and steelhead programs overall would have a negligible negative population viability benefit on natural-origin chum salmon in the Duwamish-Green River Basin (Table 37) because all population viability benefits to natural-origin chum salmon from the hatchery program would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which all would have a negligible positive population viability benefit).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to existing conditions, Alternative 1, and Alternative 2, and the integrated chum salmon hatchery program would release 2,500,000 fewer hatchery-origin chum salmon fry than under existing conditions, Alternative 1, and Alternative 2 (Table 28). Because of this substantial reduction in the number of chum salmon released, fewer hatchery-origin chum salmon would return to the river basin; thus, the population viability benefits from the hatchery program to the abundance, diversity, and spatial structure of natural-origin chum salmon would be reduced.

In summary, under Alternative 4, considering all potential population viability parameters, the integrated chum salmon hatchery program overall would have a negligible positive population viability benefit to natural-origin chum salmon in the Duwamish-Green River Basin (Table 37), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because although the number of chum salmon fry would be reduced, the number of fry released would be substantial, and all other aspects of the program would be the same as under existing conditions, Alternative 1, and Alternative 2. Relative to Alternative 3 (negligible negative), population viability benefits under Alternative 4 would be increased because the hatchery program would be terminated under Alternative 3, thereby eliminating the potential for population viability benefits to natural-origin chum salmon.

4.2.8 Nutrient Cycling

When adult salmon and steelhead return from the ocean to spawn and eventually die in rivers and streams, marine-derived nutrients from decomposing carcasses are released into freshwater ecosystems that are beneficial to juvenile salmon and steelhead, other fishes, aquatic invertebrates, and wildlife (Subsection 3.2.3.8, Nutrient Cycling). These marine-derived nutrients are contributed from natural-origin and hatchery-origin salmon and steelhead that spawn naturally, and from of carcasses that are placed in streams by people as a result of hatchery operations. Hatchery programs for fall-run Chinook salmon, steelhead, and coho salmon in the Duwamish-Green River Basin may contribute over 28 percent of the carcasses and associated marine-derived nutrients to the river basin each year (Table 19). However, although they provide beneficial contributions of marine-derived nutrients, current contributions from salmon and steelhead are well below the historical levels of marine-derived nutrients that were deposited into watersheds when returns of natural-origin salmon and steelhead to Puget Sound rivers were much larger.

In summary, considering all nutrient cycling effects, the existing salmon and steelhead hatchery programs overall have a low positive nutrient cycling effect on the aquatic ecosystem and natural-origin salmon and steelhead under existing conditions (Table 38), primarily because the annual escapement of hatchery-origin coho salmon, steelhead, and fall-run Chinook salmon spawners and distribution of carcasses from hatchery operations in the Duwamish-Green River Basin contribute over 28 percent of the total number of carcasses and associated marine-derived nutrients to the river basin.

Table 38. Comparative summary of effects of nutrient cycling on natural-origin salmon and steelhead under the alternatives.

Natural-origin Species	Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
All Salmon and Steelhead	Low positive	Low positive	Low positive	Low negative	Low positive

Alternative 1: Under Alternative 1, the seven existing hatchery programs would continue to operate as under existing conditions, and would release up to 12,443,000 salmon and steelhead annually (Table 28). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 fall-run Chinook salmon, steelhead, and coho salmon juveniles would be released from three new FRF hatchery programs (Table 28). As shown in Table 27, there would be two different scenarios for releases of hatchery-origin fish from the new FRF hatchery programs associated with potential fish passage at Howard Hanson Dam. The fish released from the new FRF hatchery programs would have the potential to increase the contributions of marine derived nutrients relative to existing conditions, because of the additional production and release locations in the upper river, including juvenile releases and distributions of carcasses from hatchery operations above the dam if fish passage exists. However, the number of adults returning from the new FRF hatchery programs and associated release scenarios would be unlikely to substantially increase the contributions of marine-derived nutrients to the Duwamish-Green River Basin compared to existing conditions, especially in the near term, although the programs may increase the number of carcasses to some extent over the long term.

In summary, under Alternative 1, considering all potential nutrient cycling benefits, the salmon and steelhead hatchery programs overall would have a low positive nutrient cycling effect on the aquatic ecosystem and natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 38), which would be the same as under existing conditions, primarily because the annual escapement of hatchery-origin coho salmon, steelhead, and fall-run Chinook salmon spawners and distribution of carcasses from hatchery operations in the Duwamish-Green River Basin would contribute over 28 percent of the total number of carcasses and associated marine-derived nutrients to the river basin. The new FRF hatchery programs may increase the number of carcasses from natural spawners over the long term, which would contribute to the low positive effect.

Alternative 2: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would total 13,993,000 juveniles, which would be same as under Alternative 1 and 1,550,000 more than under existing conditions (Table 28). The contribution of marine-derived nutrients from escapement of hatchery-origin coho salmon, steelhead, and fall-run Chinook salmon spawners and distribution of carcasses from hatchery operations would be the same as under existing conditions and Alternative 1.

In summary, under Alternative 2, considering all potential nutrient cycling benefits, the salmon and steelhead hatchery programs overall would have a low positive nutrient cycling effect on the aquatic ecosystem and natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 38), which would be the same as under existing conditions and Alternative 1, primarily because the annual escapement of hatchery-origin coho salmon, steelhead, and fall-run Chinook salmon spawners and distribution of carcasses from hatchery operations in the Duwamish-Green River Basin would contribute over 28 percent of the total number of carcasses and associated marine-derived nutrients to the river basin. The new FRF hatchery programs may increase the number of carcasses from natural spawners over the long term, which would contribute to the low positive effect.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release up to 12,443,000 salmon and steelhead as under existing conditions, Alternative 1, and Alternative 2, and the additional 1,550,000 salmon and steelhead juveniles produced by the new FRF hatchery programs under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all nutrient cycling effects on the aquatic ecosystem associated with the ongoing and proposed new programs would be discontinued relative to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 3, considering all potential nutrient cycling benefits, the salmon and steelhead hatchery programs overall would have a low negative nutrient cycling effect on the aquatic ecosystem and natural-origin salmon and steelhead in the Duwamish-Green River Basin (Table 38), because all nutrient cycling benefits to the aquatic ecosystem from the hatchery program would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2 (which would all have a low positive nutrient cycling effect).

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release up to 6,996,500 fewer hatchery-origin salmon and steelhead from ongoing and proposed new FRF hatchery programs than under existing conditions, Alternative 1, and Alternative 2 (Table 28). Although fewer fish would be produced under Alternative 4 compared to Alternative 1 and Alternative 2, nutrient cycling effects on the aquatic ecosystem in the Duwamish-Green River Basin and natural-origin salmon and steelhead would be the similar to those under existing conditions, Alternative 1, and Alternative 2, primarily because although reduced, the escapements of hatchery-origin coho salmon, steelhead, and fall-run Chinook salmon spawners and distribution of carcasses from hatchery operations would still be substantial.

In summary, under Alternative 4, considering all potential nutrient cycling benefits, the salmon and steelhead hatchery programs overall would have a low positive nutrient cycling effect on the aquatic ecosystem in the Duwamish-Green River Basin (Table 38), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because although reduced, the escapements of hatchery-origin coho salmon, steelhead, and fall-run Chinook salmon spawners and distribution of carcasses from hatchery operations would still be substantial. In comparison to Alternative 3 (low negative), nutrient cycling benefits under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for nutrient cycling effects.

4.3 Other Fish Species

The analysis of other fish species addresses effects of existing and proposed salmon and steelhead hatchery programs in the Duwamish-Green River Basin under each alternative relative to existing conditions for fish species other than salmon and steelhead that have a relationship to salmon and steelhead, as described in Subsection 3.3, Other Fish Species. The analysis focuses on natural-origin fish species that are self-sustaining in the natural environment and are dependent on aquatic habitat for migration, spawning, rearing, and food. Hatchery-origin fish can be predators or prey for other fish species, depending on the species (Subsection 3.3, Other Fish Species). For example, the low numbers of threatened bull trout in the Duwamish-Green River Basin may be positively affected to the extent they prey on releases of hatchery-origin salmon and steelhead from the hatchery programs; however, this species typically uses a variety of food sources, and the river basin is not a current or historic core area for the species within the Coastal Recovery Unit.

In summary, considering all potential effects, the existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall, have a negligible effect on other fish species (positive for some species and negative for others) (Table 39), because (1) the analysis area is only a small portion of each species' range, and (2) hatchery-origin salmon and steelhead are not exclusive predators or prey for any of the other fish species (including bull trout).

Table 39. Comparative summary of effects on other fish species under the alternatives for the Duwamish-Green River Basin.

Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Negligible (positive or negative depending on species)	Negligible (positive or negative depending on species)	Negligible (positive or negative depending on species)	Negligible (positive or negative depending on species)	Negligible (positive or negative depending on species)

4.3.1 Alternative 1 (No Action) – Do Not Make a Determination under the 4(d) Rule

Under Alternative 1, the hatchery programs would operate the same as under existing conditions and produce the same number of juvenile fish. In addition, the three new FRF hatchery programs would be implemented. Up to 13,993,000 salmon and steelhead would be produced, including the 1,550,000 juvenile salmon and steelhead from the three new FRF hatchery programs, relative to existing conditions, under which up to 12,443,000 salmon and steelhead would be produced (Subsection 3.2, Salmon and Steelhead) (Table 28).

Two release scenarios for FRF hatchery programs are possible under Alternative 1 as shown in Table 27, depending on whether fish passage is available at Howard Hanson Dam. If fish passage is not available at the dam under Alternative 1, all of the juvenile salmon and steelhead produced by the FRF hatchery programs would be released below the dam as subyearlings (fall-run Chinook salmon) or yearlings (late winter-run steelhead and coho salmon). If fish passage is available, then 1,280,000 of the juveniles produced by the FRF hatchery programs would be released above the dam as subyearlings and fry (Table 27) (at younger life stages and smaller sizes than yearlings).

Under Alternative 1, effects of the salmon and steelhead released from the hatcheries on other fish species (including bull trout) would be similar to existing conditions (Subsection 3.3, Other Fish Species). These effects would be both negative (e.g., hatchery-origin fish that compete with or prey on other fish species) and positive (e.g., other fish species that consume hatchery-origin salmon and steelhead). Under Alternative 1, the hatchery programs would have a greater effect on bull trout compared to existing conditions, because there would be more hatchery-origin salmon and steelhead juveniles from the new FRF hatchery programs for bull trout to eat, regardless of release scenario. Bull trout may have historically occurred upstream of the dam (Subsection 3.3, Other Fish Species). If fish passage is provided at Howard Hanson Dam, the salmon and steelhead juveniles released from the FRF upstream of the dam would be a food source that could lead to increased bull trout abundance in that area. For other fish species under both FRF release scenarios, the risks to other fish species from competition for food and space and from predation (especially from steelhead and coho salmon yearling releases) would increase under Alternative 1 compared to existing conditions because of the larger size of the yearlings as potential predators compared to the smaller subyearlings and fry.

In summary, under Alternative 1, considering all potential effects, the salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall, would have a negligible effect on other fish species (positive for some species and negative for others) (Table 39) because (1) the analysis area is only a small portion of each species' range, and (2) hatchery-origin salmon and steelhead are not exclusive predators or prey for any of the other fish species (including bull trout), which would be the same as under existing conditions. Under Alternative 1, no short- or long-term changes would be expected in risks to other fish species or state or Federal species designations relative to existing conditions (Subsection 3.3, Other Fish Species).

4.3.2 Alternative 2 (Proposed Action) – Make a Determination that the Submitted HGMPs Meet the Requirements of the 4(d) Rule

Under Alternative 2, the hatchery programs would operate as proposed in the submitted HGMPs (Subsection 2.2.2, Alternative 2). Under Alternative 2, up to 13,993,000 salmon and steelhead juveniles would be produced, the same as under Alternative 1, including up to 1,550,000 juveniles from the three FRF hatchery programs, which would be greater than the 12,443,000 fish produced under existing conditions (Table 28). In addition, if fish passage is not provided at Howard Hanson Dam under Alternative 2, all of the juvenile salmon and steelhead produced by the FRF hatchery programs would be released below the dam as subyearlings or yearlings, which would be same as under Alternative 1. If fish passage is provided, then up to 1,280,000 of the juveniles produced by the FRF hatchery programs would be released above Howard Hanson Dam at younger life stages and at smaller sizes (as subyearlings and fry) (Table 27), which would be the same as Alternative 1.

Under Alternative 2, the salmon and steelhead released from hatcheries would affect other fish species (including bull trout), which would be similar to Alternative 1 and existing conditions (Subsection 3.3, Other Fish Species). These effects would be both negative (e.g., hatchery-origin fish that compete with and prey on other fish species) and positive (e.g., other fish species that consume hatchery-origin salmon and steelhead). Under Alternative 2, the hatchery programs would have a greater effect on bull trout compared to existing conditions, which would be the same as under Alternative 1, because there would be more hatchery-origin salmon and steelhead juveniles from the new FRF hatchery programs for bull trout to eat, regardless of release scenario.

The risks to other fish species under both FRF release scenarios from competition for food and space and from predation (especially from steelhead and coho salmon yearlings), would increase slightly under Alternative 2 and Alternative 1, compared to existing conditions, due to releases from FRF programs.

In summary, under Alternative 2, considering all potential effects, the salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall, would have a negligible effect on other fish species (positive for some species and negative for others) (Table 39), because (1) the analysis area is only a small portion of each species' range, and (2) hatchery-origin salmon and steelhead are not exclusive predators or prey for any of the other fish species (including bull trout), which would be the same as under Alternative 1 and existing conditions. Under Alternative 2, no short- or long-term changes would be expected in risks to other fish species or state or Federal species designations relative to Alternative 1 or existing conditions (Subsection 3.3, Other Fish Species).

4.3.3 Alternative 3 (Termination) – Make a Determination that the Submitted HGMPs Do Not Meet the Requirements of the 4(d) Rule

Under Alternative 3, the existing and new hatchery programs would be terminated (Subsection 2.2.3, Alternative 3), and up to 12,443,000 fewer hatchery-origin salmon and steelhead would be produced by the hatcheries in the Duwamish-Green River Basin relative to existing conditions (Subsection 3.3, Other Fish Species), and up to 13,993,000 fewer would be produced than under Alternative 1 and Alternative 2, which include fish from the new FRF hatchery programs (Table 28). Under Alternative 3, the reduction in salmon and steelhead releases would reduce short- and long-term competition with other species for space and food, compared to existing conditions, Alternative 1, and Alternative 2. In addition, there would be a reduction in predation risk by hatchery-origin salmon and steelhead on other fish species and a reduction in the number of hatchery-origin juveniles available as prey for other fish species (including bull trout) in the analysis area relative to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 3, considering all potential effects, the salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a negligible effect on other fish species (positive for some species and negative for others) (Table 39) because (1) the analysis area is only a small portion of each species' range, and (2) hatchery-origin salmon and steelhead are not exclusive predators or prey for any of the other fish species (including bull trout), which would be a similar level of effect but in the opposite direction for other fish species compared to existing conditions, Alternative 1, and Alternative 2. Under Alternative 3, no short- or long-term changes would be expected in risks to other fish species or state or Federal species designations relative to existing conditions, Alternative 1, and Alternative 2 (Subsection 3.3, Other Fish Species).

4.3.4 Alternative 4 (Reduced Production) – Make a Determination that the Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

Under Alternative 4, production from the existing and new salmon and steelhead hatchery programs would be reduced 50 percent (Subsection 2.2.4, Alternative 4), compared to Alternative 1 and Alternative 2. Up to 4,946,500 fewer salmon and steelhead would be released from hatcheries in the Duwamish-Green River Basin compared to existing conditions, and up to 6,996,500 fewer salmon and steelhead would be released compared to Alternative 2 and Alternative 1 (Table 28). Under Alternative 4, up to 6,996,500 more salmon and steelhead would be released than under Alternative 3, wherein the hatchery programs would be terminated.

Under Alternative 4, effects on other fish species (including bull trout) from salmon and steelhead released from the hatcheries would similar to but less than under existing conditions, Alternative 1, and Alternative 2, primarily because the number of fish released would be less. These effects would be both negative (e.g., hatchery-origin fish that compete with and prey on other fish species) and positive (e.g., other fish species that consume hatchery-origin salmon and steelhead). Under Alternative 4, the hatchery programs would have a smaller effect on bull trout compared to existing conditions, Alternative 1, and Alternative 2, because there would be fewer hatchery-origin salmon and steelhead juveniles for bull trout to eat, regardless of release scenario.

In summary, under Alternative 4, considering all potential effects, the salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall, would have a negligible effect on other fish species (positive for some species and negative for others) (Table 39) because (1) the analysis area is only a small portion of each species' range, and (2) hatchery-origin salmon and steelhead are not exclusive predators or prey for any of the other fish species (including bull trout), which would be the same as under existing conditions, Alternative 1, and Alternative 2. Under Alternative 4, no short- or long-term risks to other fish species or state or Federal species designations would be expected relative to existing conditions, Alternative 1, Alternative 2, and Alternative 3. In comparison to Alternative 3 (negligible), effects on other fish species under Alternative 4 would be increased or decreased (depending on the species) because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for effects on other fish species.

4.4 Wildlife – Southern Resident Killer Whale

The analysis of wildlife (Southern Resident killer whale) addresses effects of existing and proposed salmon and steelhead hatchery programs in the Duwamish-Green River Basin under each alternative relative to existing conditions for Southern Resident killer whales, as described in Subsection 3.4, Wildlife – Southern Resident Killer Whale. As described in Subsection 3.4, Wildlife – Southern Resident Killer Whale, effects of salmon and steelhead hatchery programs on other wildlife species would likely be generally unsubstantial, and wildlife species in the analysis area would continue to occupy their existing habitats in similar abundances and feed on a variety of prey, including salmon and steelhead. Therefore, as described in Subsection 3.4, Wildlife – Southern Resident Killer Whale, wildlife species in the analysis area are not analyzed in this EIS, with the exception of Southern Resident killer whales. Effects of existing salmon and steelhead hatchery programs on Southern Resident killer whales are analyzed in this EIS because of their special interest to the public (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

Southern Resident killer whales are listed under the ESA and are present in the analysis area. Adult Chinook salmon are a primary component of their diet during the summer and are also important in the winter, and chum salmon are also important during the fall (Subsection 3.4, Wildlife – Southern Resident Killer Whale). Adult hatchery-origin Chinook salmon represent 74 percent of the total number of Chinook salmon (hatchery-origin and natural-origin) returning to Puget Sound (Subsection 3.4, Wildlife – Southern Resident Killer Whale). Therefore, it is highly likely that the hatchery-origin adult salmon (especially Chinook salmon) contribute to the diet of the whales in Puget Sound.

Fraser River Chinook salmon stocks are an important component of the Southern Resident killer whale summer diet in the vicinity of the San Juan Islands and the western Strait of Juan de Fuca, British Columbia. Only 6 to 14 percent of the Chinook salmon prey in these areas originate in Puget Sound river basins (Subsection 3.4, Wildlife – Southern Resident Killer Whale). When considering all adult natural-origin and hatchery-origin salmon and steelhead in Puget Sound that are part of the food base for Southern Resident killer whales (originating from watersheds and hatcheries in Puget Sound, and salmon originating in Canadian waters that pass through Puget Sound), the contribution of adult hatchery-origin salmon and steelhead under existing conditions is likely unsubstantial (Subsection 3.5.3.1.1, Killer Whale, in the PS Hatcheries DEIS [NMFS 2014a]).

In addition, as described in Subsection 3.4, Wildlife – Southern Resident Killer Whale, the contribution of hatchery programs in the Duwamish-Green River Basin to the prey base for Southern Resident killer whales is likely minimal. For example, under existing conditions, up to 4,500,000 fall-run Chinook salmon are released (Table 28), producing an estimated average return of 19,395 adults that are available as prey for Southern Resident killer whales and for harvest. In contrast, the estimated total annual abundance of Chinook salmon from Washington State and British Columbia waters that is available for Southern Resident killer whales is much larger, averaging approximately 1,000,000 fish (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

In summary, considering all potential effects on Southern Resident killer whales, the existing salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall have a negligible positive effect (Table 40) on the diet, survival, distribution, and listing status of Southern Resident killer whales, primarily because adults returning from the hatchery programs (especially Chinook salmon) represent a small part of the Southern Resident killer whale food base provided by the total number of hatchery-origin and natural-origin salmon and steelhead available from throughout the greater Puget Sound, the Strait of Georgia, and Pacific Coast area, particularly during the fall months.

Table 40. Comparative summary of effects on wildlife (Southern Resident killer whale) under the alternatives.

Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Negligible positive	Negligible positive	Negligible positive	Negligible negative	Negligible positive

4.4.1 Alternative 1 (No Action) – Do Not Make a Determination under the 4(d) Rule

Under Alternative 1, the hatchery programs would operate as proposed in the submitted HGMPs. Compared to existing conditions, three new FRF hatchery programs would be implemented. Up to 13,993,000 salmon and steelhead would be produced (up to 5,100,000 fall-run Chinook salmon), which would include production from the new FRF hatchery programs of up to 1,550,000 juvenile salmon and steelhead (up to 600,000 fall-run Chinook salmon) relative to existing conditions, under which up to 12,443,000 fish (including up to 4,500,000 fall-run Chinook salmon) are produced (Table 28). Chum salmon would not be produced by FRF hatchery programs.

If fish passage is not provided at Howard Hanson Dam under Alternative 1, all of the juvenile salmon and steelhead produced by the FRF hatchery programs would be released below the dam as subyearlings or yearlings. If fish passage is provided, then up to 1,280,000 of the juveniles produced by the FRF hatchery programs would be released above the dam at younger life stages and at smaller sizes (as subyearlings and fry) (Table 27). The 600,000 fall-run Chinook salmon juveniles released from the new FRF hatchery program under Alternative 1 would be expected to increase the average number of adults available as prey and for harvest by 617 fish if fish passage is available at the dam, or 2,466 fish if passage is not available at the dam, compared to the 19,395 adults that are available under existing conditions (Tim Tynan, NMFS, email sent to Steve Leider, Fish Biologist, NMFS, February 2, 2017, regarding the number of hatchery-origin Chinook salmon from hatchery programs in the Duwamish-Green River Basin). The differences in the numbers of adults associated with the two passage scenarios reflect differences in numbers of juveniles released by life stage (i.e., the smolt-to-adult survival rate for younger and smaller fish [e.g., fry] is generally less than for older and larger fish [e.g., smolts]). As under existing conditions, the estimated total annual abundance of adult Chinook salmon from Washington State and British Columbia waters that would be available as food for Southern Resident killer whales would average about 1,000,000 fish (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

In summary, under Alternative 1, considering all potential effects, the existing and new salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a negligible positive effect (Table 40) on the diet, survival, distribution, and listing status of Southern Resident killer whales, which would be the same as under existing conditions. This is because the returning hatchery-origin adults (especially Chinook salmon) would represent a small part of the food base for Southern Resident killer whales provided by the total number of hatchery-origin and natural-origin salmon and steelhead available from throughout the greater Puget Sound, the Strait of Georgia, and Pacific Coast areas, particularly during the fall months.

4.4.2 Alternative 2 (Proposed Action) – Make a Determination that the Submitted HGMPs Meet the Requirements of the 4(d) Rule

Under Alternative 2, the hatchery programs would operate as proposed in the submitted HGMPs and would produce the same number of juvenile fish as under Alternative 1. Under Alterative 2 and Alternative 1, up to 13,993,000 salmon and steelhead would be produced (including up to 5,100,000 fall-run Chinook salmon), compared to existing conditions under which up to 12,443,000 fish are produced (including up to 4,500,000 Chinook salmon). Under Alternative 2 and Alternative 1, up to 1,550,000 juvenile salmon and steelhead would be produced by the new FRF hatchery programs (including up to 600,000 fall-run Chinook salmon) (Table 28). No chum salmon would be produced by the new FRF hatchery programs, which would be the same as under

Alternative 1. Adult Chinook salmon and chum salmon (especially Chinook salmon) are preferred prey of Southern Resident killer whales during specific times of the year (Subsection 3.4, Wildlife – Southern Resident Killer Whale) (PS Hatcheries DEIS [NMFS 2014a]).

If fish passage is not provided at Howard Hanson Dam under Alternative 2, all of the juvenile salmon and steelhead produced by the FRF hatchery programs would be released below the dam as subyearlings or yearlings, which is the same as under Alternative 1. If fish passage is provided, then up to 1,280,000 of the juveniles produced by the FRF hatchery programs would be released above the dam at younger life stages and at smaller sizes (as subyearlings and fry) (Table 27), which is the same as under Alternative 1. As under Alternative 1, the 600,000 fall-run Chinook salmon juveniles released from the new FRF hatchery program under Alternative 2 would be expected to increase the average number of adults available as prey and for harvest by 617 fish if fish passage is available at the dam, or 2,466 fish if passage is not available at the dam, compared to the 19,395 adults that are available under existing conditions (Tim Tynan, NMFS, email sent to Steve Leider, Fish Biologist, NMFS, February 2, 2017, regarding the number of hatchery-origin Chinook salmon from hatchery programs in the Duwamish-Green River Basin). The differences in the numbers of adults associated with these passage scenarios reflect differences in numbers of juveniles released by life stage (i.e., the smolt-to-adult survival rate for younger and smaller fish [e.g., fry] is generally less than for older and larger fish [e.g., smolts]). As under existing conditions and Alternative 1, the estimated total annual abundance of adult Chinook salmon from Washington State and British Columbia waters that would be available as food for Southern Resident killer whales would average about 1,000,000 fish (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

In summary, under Alternative 2, considering all potential effects, the existing and new salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a negligible positive effect (Table 40) on the diet, survival, distribution, and listing status of Southern Resident killer whales, which would be the same as under Alternative 1 and existing conditions. This is because the returning hatchery-origin adults (especially Chinook salmon) would represent a small part of the food base for Southern Resident killer whales provided by the total number of hatchery-origin and natural-origin salmon and steelhead available from throughout the greater Puget Sound, the Strait of Georgia, and Pacific Coast areas, particularly during the fall months.

4.4.3 Alternative 3 (Termination) – Make a Determination that Submitted HGMPs Do Not Meet the Requirements of the 4(d) Rule

Under Alternative 3, the existing and new hatchery programs would be terminated (Subsection 2.2.3, Alternative 3), and up to 12,443,000 fewer hatchery-origin salmon and steelhead would be produced by the hatcheries in the Duwamish-Green River Basin relative to existing conditions (Subsection 3.3, Other Fish Species), and up to 13,993,000 fewer would be produced than under Alternative 1 and Alternative 2, which would include fish from the new FRF hatchery programs (Table 28). Under Alternative 3, the reduction in salmon and steelhead releases would result in short- and long-term reductions in the number of salmon and steelhead adults that would be available as food for Southern Resident killer whales (up to 21,861 fewer adult fall-run Chinook salmon relative to Alternative 1 and Alternative 2, and up to 19,395 fish under existing conditions). However, as under existing conditions, Alternative 1, and Alternative 2, the estimated total annual abundance of adult Chinook salmon from Washington State and British Columbia that would be available as food for Southern Resident killer whales would average about 1,000,000 fish (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

In summary, under Alternative 3, considering all potential effects, the existing and new salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a negligible negative effect (Table 40) on the diet, survival, distribution, and listing status of Southern Resident killer whales, which would be in the opposite direction compared to existing conditions, Alternative 1, and Alternative 2, (which would all have a negligible positive effect). This is because the hatchery programs in the Duwamish-Green River Basin would not contribute to the food base (especially Chinook salmon) for Southern Resident killer whales; however, the total number of hatchery-origin and natural-origin salmon and steelhead that would be available from throughout the greater Puget Sound, the Strait of Georgia, and Pacific Coast areas, particularly during the fall months, would be substantial.

4.4.4 Alternative 4 (Reduced Production) – Make a Determination that the Revised HGMPs with Reduced Production Levels Meet the Requirements of the 4(d) Rule

Under Alternative 4, production from the existing and new salmon and steelhead hatchery programs would be reduced by 50 percent (Subsection 2.2.4, Alternative 4), compared to Alternative 2 and Alternative 1. Up to 5,446,500 fewer salmon and steelhead (including up to 1,950,000 fewer fall-run Chinook salmon) would be released from hatcheries in the Duwamish-Green River Basin compared to existing conditions, and up to 6,996,500 fewer salmon and steelhead (including up to 2,550,000 fewer fall-run Chinook salmon), would be released compared to Alternative 2 and Alternative 1 (Table 28). Under Alternative 4, up to 6,996,500 more salmon and steelhead would be released than under

Alternative 3, wherein the hatchery programs would be terminated. The new FRF fall-run Chinook salmon hatchery program would produce up to 300,000 fewer subyearlings and/or fry (Table 27) than under Alternative 1 and Alternative 2. None of the new FRF hatchery programs would produce chum salmon, as under Alternative 1 and Alternative 2. The reductions in salmon and steelhead releases under Alternative 4 would result in short- and long-term reductions in the number of salmon and steelhead adults that would be available as food for Southern Resident killer whales. Chinook salmon and chum salmon (especially Chinook salmon) are preferred prey of Southern Resident killer whales during specific times of the year and at specific locations within Puget Sound (Subsection 3.4, Wildlife – Southern Resident Killer Whale) (PS Hatcheries DEIS [NMFS 2014a]).

If fish passage is not provided at Howard Hanson Dam under Alternative 4, all of the juvenile salmon and steelhead produced by the FRF hatchery programs would be released below the dam as subyearlings or yearlings, which is the same as under Alternative 1 and Alternative 2. If fish passage is provided, then up to 1,280,000 of the juveniles produced by the FRF hatchery programs would be released above the dam at younger life stages and at smaller sizes (as subyearlings and fry) (Table 27). The 300,000 fall-run Chinook salmon juveniles released from the new FRF hatchery program under Alternative 4 would be expected to increase the average number of adults available as prey and for harvest by about 300 fish if fish passage is available at the dam, or about 1,200 fish if passage is not available at the dam, compared to the 19,395 adults that are available under existing conditions (Tim Tynan, NMFS, email sent to Steve Leider, Fish Biologist, NMFS, February 2, 2017, regarding the number of hatchery-origin Chinook salmon from hatchery programs in the Duwamish-Green River Basin). The differences in the numbers of adults associated with these passage scenarios reflect differences in numbers of juveniles released by life stage (i.e., the smolt-to-adult survival rate for younger and smaller fish [e.g., fry] is generally less than for older and larger fish [e.g., smolts]). As under existing conditions, Alternative 1, and Alternative 2, the estimated total annual abundance of adult Chinook salmon from Washington State and British Columbia waters that would be available as food for Southern Resident killer whales would average about 1,000,000 fish (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

In summary, under Alternative 4, considering all potential effects, the existing and new salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a negligible positive effect (Table 40) on the diet, survival, distribution, and listing status of Southern Resident killer whales, which would be the same as under existing conditions, Alternative 1, and Alternative 2. This is because adults returning from the hatchery programs (especially Chinook salmon) would represent a small part of the Southern Resident killer whale food base provided by the total number of hatchery-origin and natural-origin salmon and steelhead available from throughout the greater Puget Sound, the Strait of Georgia, and Pacific Coast areas, particularly during the fall months. In comparison to Alternative 3 (negligible negative), effects on Southern Resident killer whales under Alternative 4 would be increased (neglible positive) because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for effects on Southern Resident killer whales.

4.5 Socioeconomics

The socioeconomic analysis addresses effects from existing and new salmon steelhead and hatchery programs in the Duwamish-Green River Basin under each alternative relative to existing conditions as described in Subsection 3.5, Socioeconomics. The analysis focuses on effects under the alternatives on the number of fish harvested in commercial fisheries and the number of angler trips in recreational fisheries, economic values associated with commercial (ex-vessel values) and recreational fisheries (trip-related expenditures), hatchery program costs, and direct and indirect contributions to employment and personal income in the regional and local economies.

This analysis evaluates the socioeconomic contributions of the seven existing hatchery programs and the three new FRF hatchery programs. As for other resources, the analysis of the new FRF hatchery programs includes two release scenarios that pertain to whether fish passage is available at Howard Hanson Dam (Chapter 4 [Introduction]) (Table 26). Releases of juvenile fish at older ages (e.g., as subyearlings or yearlings) generally result in higher rates of survival to adult return than releases of younger fish (e.g., fry) (Subsection 3.2, Salmon and Steelhead), which affects the number of adults available for harvest. Detailed information on methods used to analyze the socioeconomic resource is presented in Appendix B, Socioeconomics. Impacts of the alternatives are analyzed at the basin (local) and regional (Puget Sound-wide) scales. For this EIS, impacts at the regional scale are analyzed in the context of all regional salmon and steelhead fishing activity (Puget Sound-wide) using the 2010 to 2014 time frame, the most recent 5-year period for which complete data are available.

As in Subsection 3.5, Socioeconomics, values in the following subsections are not rounded to aid the reader in finding corresponding numbers between tables and text. The use of unrounded numbers, however, should not be interpreted as suggestive of unusually high levels of precision in the estimates. All numbers presented represent a reasonable estimate of the underlying values. Information on methods and analyses used in this analysis is presented in Appendix B, Socioeconomics.

The numbers of jobs identified in this analysis are expressed as FTE jobs. Most jobs in the commercial fishing industry are part-time positions due to the seasonality of commercial salmon fishing in Puget Sound. Many persons engaged in commercial salmon fishing also participate in other fisheries and/or have other occupations. This situation should be considered in interpreting the employment effects presented below related to changes in commercial salmon harvest (and to a lesser extent, jobs associated with recreational fishing).

Hatcheries in the Duwamish-Green River Basin also provide salmon and steelhead for ceremonial and subsistence fishing, as discussed in Subsection 3.6, Environmental Justice, and Subsection 4.6, Environmental Justice.

As described in Subsection 3.5, Socioeconomics, under existing conditions, the annual commercial catch of Chinook salmon, coho salmon, chum salmon, and steelhead in Puget Sound waters from hatchery programs in the Duwamish-Green River Basin is estimated to be 139,292 fish, with 90 percent of these fish caught in tribal fisheries and 10 percent caught in non-tribal fisheries. Over 99 percent of this harvest occurs in King County. Recreational fisheries targeting salmon and steelhead produced from these hatchery programs annually result in 53,856 trips that generate $9,469,026 in trip-related expenditures. Most of these trips originate in the South Puget Sound subregion, and about 82 percent originate in King County. Hatchery operations for the seven existing salmon and steelhead hatchery programs generate 18.1 jobs and $868,856 in personal income (direct and indirect) that contribute to the regional economy. These effects occur almost entirely in King County because that is where the hatcheries are located.

The commercial harvest of salmon and steelhead produced by hatchery programs in the Duwamish-Green River Basin generates (directly and indirectly) 18.9 jobs and $1,468,133 in personal income in the socioeconomic analysis area. The vast majority of these jobs and personal income (96 percent) occur within King County. Recreational fishing activities targeting salmon and steelhead produced by the hatchery programs generate a total of 171.2 jobs and $10,037,720 in personal income in the socioeconomic analysis area, with most jobs and income occurring in the South Puget Sound subregion. The hatchery programs contribute 3.2 percent of the salmon and steelhead harvested commercially in the socioeconomic analysis area, and 4.2 percent of their ex-vessel value. Similarly, the hatchery programs support 3.6 percent of the recreational fishing trips and trip-related expenditures for salmon and steelhead in the socioeconomic analysis area. Commercial fishing for salmon and steelhead produced by the hatcheries supports 3.2 percent of the jobs and 4.6 percent of the total personal income associated with all salmon and steelhead commercially harvested in the socioeconomic analysis area. Finally, the average total number of jobs and personal income associated with recreational fishing for salmon and steelhead produced by the hatcheries represents 4.8 percent of all jobs and 4.7 percent of the total personal income associated with all recreational fishing for salmon and steelhead in the socioeconomic analysis area.

In summary, under existing conditions, considering all socioeconomic effects, the hatchery programs in the Duwamish-Green River Basin have a low positive effect (Table 41) across the socioeconomic analysis area overall (Subsection 3.5, Socioeconomics). This is because, although the hatchery programs generate income from commercial and recreational fisheries and hatchery operations, and they contribute to regional and local economies, the most substantial impacts accrue to tribal commercial and non-tribal recreational fisheries in the South Puget Sound subregion, particularly in King County. However, in some of the more remote areas and communities of the Duwamish-Green River Basin in the South Puget Sound subregion, the effect would be greater because some local economies are more economically dependent on the direct and indirect economic effects of the hatchery programs.

Table 41. Comparative summary of socioeconomic effects under the alternatives.

Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Low positive	Low positive	Low positive	Low negative	Negligible positive

4.5.1 Alternative 1 (No Action) – Do Not Make a Determination under the 4(d) Rule

Under Alternative 1, the hatchery programs would operate the same as under existing conditions and produce the same number of juvenile fish, with similar socioeconomic conditions as described in Subsection 3.5, Socioeconomics. In addition, the three new FRF hatchery programs would be implemented. Up to 13,993,000 salmon and steelhead would be produced, including the 1,550,000 juvenile salmon and steelhead from the three FRF hatchery programs, compared to existing conditions, under which 12,443,000 salmon and steelhead would be produced annually (Table 27).

Two release scenarios for the new FRF hatchery programs are possible under Alternative 1 as shown in Table 26, depending on whether fish passage is available at Howard Hanson Dam. If fish passage is not available at the dam under Alternative 1, all of the juvenile salmon and steelhead produced by the FRF hatchery programs would be released below the dam as subyearlings or yearlings. If fish passage is available, then 1,280,000 of the juveniles produced by the FRF hatchery programs would be released above the dam as subyearlings and fry (Table 26) (at younger life stages and at smaller sizes than yearlings).

4.5.1.1 Fisheries Affected by the Hatchery Programs

Commercial Fisheries: Under Alternative 1, the contribution of the 10 existing and new hatchery programs to the commercial harvest (numbers of fish and ex-vessel value) of salmon and steelhead in Puget Sound waters would increase compared to existing conditions because of the addition of the three new FRF hatchery programs (Table 42). The extent of harvest and economic increases under Alternative 1 would vary depending on the release scenario for the three FRF hatchery programs. If there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the commercial harvest of salmon and steelhead would increase 12 percent (by 16,822 fish) compared to existing conditions (Table 42). If there is fish passage at the dam and releases of fry occur above the dam, then commercial harvest of salmon and steelhead would increase 3 percent (by 4,193 fish) compared to existing conditions (Table 42). Over 90 percent of the commercial harvest under Alternative 1 would be by tribal fishermen, regardless of FRF release scenario, and about 98 percent of the commercial harvest would occur in the South Puget Sound subregion, which is similar to existing conditions (Table 42).

Under Alternative 1, the effects on the ex-vessel values of commercial salmon and steelhead landings would be proportionately similar to the effects on commercial harvest described above. If there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the ex-vessel value of salmon and steelhead would increase 14 percent (by $119,555) compared to existing conditions (Table 42). If there is fish passage at the dam and releases of fry occur above the dam, then the ex-vessel value of salmon and steelhead would increase 3 percent (by $27,789) compared to existing conditions (Table 42). Similar to the increases in commercial harvest under Alternative 1, over 90 percent of the ex-vessel value under Alternative 1 would be to tribal fishermen, regardless of FRF release scenario, and about 98 percent of the ex-vessel value would accrue in the South Puget Sound subregion, which would be similar to existing conditions (Table 42).

Recreational Fisheries: Under Alternative 1, the contribution of the 10 existing and new hatchery programs to recreational fishing (recreational fishing trips and related expenditures) would increase compared to existing conditions because of the addition of the three new FRF hatchery programs (Table 43). If there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the number of recreational fishing trips for salmon and steelhead would increase 21 percent (by 11,446 trips) compared to existing conditions (Table 43). If there is fish passage at the dam and releases of fry occur above the dam, then the number of recreational fishing trips for salmon and steelhead would increase 5 percent (by 2,874 trips) compared to existing conditions (Table 43). Of the increases in recreational fishing trips, about 47 percent of the trips would occur in the South Puget Sound subregion, followed by 32 percent in the Strait of Juan de Fuca subregion, and 20 percent in the North Puget Sound subregion, regardless of release scenario (Table 43).

Under Alternative 1, the effects on trip-related expenditures from recreational fishing would be proportionately similar to those described above for recreational fishing trips. If there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, trip-related expenditures would increase 21 percent (by $2,012,449) compared to existing conditions (Table 43). If there is fish passage at the dam and releases of fry occur above the dam, then trip-related expenditures would increase 5 percent (by $505,310) compared to existing conditions (Table 43). Under Alternative 1, the distribution of the increase in trip-related expenditures among subregions would be similar to recreational fishing trips, with about 49 percent of the trip-related expenditures occurring in the South Puget Sound subregion, about 32 percent in the Strait of Juan de Fuca subregion, and 21 percent in the North Puget Sound subregion, regardless of release scenario (Table 43).

4.5.1.2 Hatchery Operations

Under Alternative 1, employment (FTE jobs) and personal income from the operation of existing hatchery programs would be the same as under existing conditions. However, additional jobs and personal income would occur from the new FRF hatchery programs, which do not occur under existing conditions. As a result, under Alternative 1 there would be a total of 21.9 jobs (an increase of 3.8 jobs) and $1,129,579 in personal income (an increase of $260,723) compared to existing conditions (Table 44). These jobs and personal income would mostly occur in King County in the South Puget Sound subregion (Table 44) because that is where the existing and new hatchery programs would operate. There would be no differences in effects on hatchery operations or employment and personal income associated with the two release scenarios for the new FRF hatchery programs.

Table 42. Contribution of salmon and steelhead hatchery programs in the Duwamish-Green River Basin to commercial harvests and ex-vessel values in Puget Sound by subregion under the alternatives.

		Alternative 1 and Alternative 2				Alternative 3		Alternative 4			
		Without Fish Passage at Howard Hanson Dam		With Fish Passage at Howard Hanson Dam				Without Fish Passage at Howard Hanson Dam		With Fish Passage at Howard Hanson Dam	
Subregion / County of Landings[1]	**Existing Conditions Number**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**
North Puget Sound											
Non-tribal											
Harvest (number)	426	452	26	433	7	0	-426	226	-200	217	-210
Ex-vessel value	$2,248	$2,413	$165	$2,292	$44	$0	-$2,248	$1,206	-$1,042	$1,146	-$1,102
Tribal											
Harvest (number)	446	458	12	438	-8	0	-446	229	-217	219	-227
Ex-vessel value	$2,495	$2,571	$76	$2,444	-$51	$0	-$2,495	$1,285	-$1,209	$1,222	-$1,273
Total											
Harvest (number)	872	910	38	871	-1	0	-872	455	-417	436	-437
Ex-vessel value	$4,743	$4,984	$241	$4,736	-$6	$0	-$4,743	$2,492	-$2,251	$2,368	-$2,375
South Puget Sound											
Non-tribal											
Harvest (number)	12,229	12,480	251	12,291	62	0	-12,229	6,240	5,989	6,146	6,083
Ex-vessel value	$61,981	$63,592	$1,611	$62,374	$393	$0	-$61,981	$31,796	-$30,185	$31,187	-$30,794
Tribal											
Harvest (number)	124,663	140,953	16,290	128,735	4,072	0	-124,663	70,477	-54,186	64,368	-60,295
Ex-vessel value	$802,295	$917,498	$115,203	$831,098	$28,803	$0	-$802,295	$458,749	-$343,546	$415,549	-$386,746
Total											
Harvest (number)	136,892	153,433	16,541	141,026	4,134	0	-136,892	76,717	-60,176	70,513	-66,379
Ex-vessel value	$864,276	$981,090	$116,813	$893,472	$29,195	$0	-$864,276	$490,545	-$373,731	$446,736	-$417,540
Strait of Juan de Fuca											
Non-Tribal											
Harvest (number)	0	0	0	0	0	0	0	0	0	0	0
Ex-vessel value	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tribal											
Harvest (number)	1,528	1,771	243	1,588	60	0	-1,528	886	-643	794	-734
Ex-vessel value	$16,849	$19,350	$2,500	$17,450	$600	$0	-$16,849	$9,675	-$7,174	$8,725	-$8,124
Total											
Harvest (number)	1,528	1,771	243	1,588	60	0	-1,528	886	-643	794	-734
Ex-vessel value	$16,849	$19,350	$2,500	$17,450	$600	$0	-$16,849	$9,675	-$7,174	$8,725	-$8,124

Table 42. Contribution of salmon and steelhead hatchery programs in the Duwamish-Green River Basin to commercial harvests and ex-vessel values in Puget Sound by subregion under the alternatives, continued.

		Alternative 1 and Alternative 2						**Alternative 4**			
		Without Fish Passage at Howard Hanson Dam		**With Fish Passage at Howard Hanson Dam**		**Alternative 3**		**Without Fish Passage at Howard Hanson Dam**		**With Fish Passage at Howard Hanson Dam**	
Subregion / County of Landings[1]	**Existing Conditions Number**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**
Puget Sound Total											
Non-tribal											
Harvest (number)	12,665	12,932	277	12,724	691	0	-12,665	6,466	6,189	6,362	-6,293
Ex-vessel value	$64,229	$66,004	$1,775	$64,666	$437	$0	-$64,229	$33,002	-$31,227	$32,333	-$31,896
Tribal											
Harvest (number)	126,637	143,182	16,545	130,761	4,124	0	-126,637	71,591	-55,046	65,381	-61,256
Ex-vessel value	$821,639	$939,419	$112,780	$850,991	$29,352	$0	-$821,639	$469,709	-$351,930	$425,496	-$396,143
Total											
Harvest (number)	139,292	156,114	16,822	143,485	4,193	0	-139,292	78,057	-61,235	71,743	-67,550
Ex-vessel value	$885,868	$1,005,423	$119,555	$915,658	$29,789	$0	-$885,868	$502,711	-$383,157	$457,829	-$428,039

Source: Values are derived based on estimates of recreational fishing effort provided by NMFS and by simulating the Puget Sound economic impact spreadsheet model developed by TCW Economics (Appendix B, Socioeconomics).

[1] Landings represent harvested fish, typically brought to shore at locations that include ports, marinas, and boat launches. This EIS generally refers to “harvest” rather than “landings.”

Notes:

Values include hatchery operations at FRF hatchery facilities to be constructed.

Values include harvest associated with all hatcheries to be operating in the Duwamish-Green River Basin, including the FRF hatchery facilities to be constructed.

All dollar values are reported in 2015 dollars.

Table 43. Contribution of salmon and steelhead hatchery programs in the Duwamish-Green River Basin to recreational fishing effort and expenditures in Puget Sound by subregion under the alternatives.

Subregion / County of Landings[1]	Existing Conditions	Alternative 1 and Alternative 2				Alternative 3		Alternative 4			
		Without Fish Passage at Howard Hanson Dam		With Fish Passage at Howard Hanson Dam				Without Fish Passage at Howard Hanson Dam		With Fish Passage at Howard Hanson Dam	
	Number	Number	Change from Existing Conditions	Number	Change from Existing Conditions	Number	Change from Existing Conditions	Number	Change from Existing Conditions	Number	Change from Existing Conditions
North Puget Sound[2]											
Trips[3]	10,204	12,520	2,316	10,795	591	0	-10,204	6,260	-3,944	5,398	-4,807
Trip-related Expenditures	$1,794,079	$2,201,281	$407,202	$1,897,990	$103,910	$0	-$1,794,079	$1,100,641	-$693,439	$948,995	-$845,085
South Puget Sound[4]											
Trips	28,684	34,107	5,423	30,040	1,356	0	-28,684	17,054	-11,631	15,020	-13,664
Trip-related Expenditures	$5,043,255	$5,996,733	$953,478	$5,281,668	$238,414	$0	-$5,043,255	$2,998,367	-$2,044,888	$2,640,834	-$2,402,421
Strait of Juan de Fuca[5]											
Trips	14,968	18,675	3,707	15,895	927	0	-14,968	9,338	-5,631	7,948	-7,021
Trip-related Expenditures	$2,631,692	$3,283,461	$651,769	$2,794,678	$162,986	$0	-$2,631,692	$1,641,730	-$989,961	$1,397,339	-$1,234,353
Puget Sound Total											
Trips	53,856	65,302	11,446	56,730	2,874	0	-53,856	32,651	-21,205	28,365	-25,491
Trip-related Expenditures	$9,469,026	$11,481,475	$2,012,449	$9,974,336	$505,310	$0	-$9,469,026	$5,740,738	-$3,728,288	$4,987,168	-$4,481,858

[1] Landings represent harvested fish, typically brought to shore at locations that include ports, marinas, and boat launches. This EIS generally refers to "harvest" rather than "landings."

[2] North Puget Sound subregion includes Whatcom and Snohomish Counties (no effects in Skagit County).

[3] Trips are an indicator of recreational fishing effort.

[4] South Puget Sound subregion includes King, Pierce, Thurston, and Kitsap Counties.

[5] Strait of Juan de Fuca subregion includes Clallam and Jefferson Counties.

Notes:

Under Alternative 1 through Alternative 4, it is assumed that there would be no change in annual operating costs at the three existing hatchery facilities, and that the annual operating costs for the three new FRF programs would generate the same proportionate numbers of FTEs and personal income as those associated with the three existing facilities (Appendix B, Socioeconomics).

All dollar values are reported in 2015 dollars.

Table 44. Personal income and jobs resulting from hatchery operations and commercial and recreational fisheries supported by salmon and steelhead hatchery programs in the Duwamish-Green River Basin under the alternatives.

Subregion / County of Landings[1]	Existing Conditions	Alternative 1 and Alternative 2				Alternative 3		Alternative 4			
		Without Fish Passage at Howard Hanson Dam		With Fish Passage at Howard Hanson Dam				Without Fish Passage at Howard Hanson Dam		With Fish Passage at Howard Hanson Dam	
	Number	Number	Change from Existing Conditions	Number	Change from Existing Conditions	Number	Change from Existing Conditions	Number	Change from Existing Conditions	Number	Change from Existing Conditions
North Puget Sound Subregion[1]											
Commercial Fisheries											
Personal Income	$7,860	$8,259	$399	$7,850	-$11	$0	-$7,860	$4,130	-$3,731	$3,925	-$3,935
Jobs	0.2	0.2	0.0	0.2	0.0	0.0	-0.2	0.1	-0.1	0.1	-0.1
Recreational Fisheries											
Personal Income	$1,901,829	$2,333,487	$431,658	$2,011,980	$110,151	$0	-$1,901,829	$1,166,743	-$735,086	$1,005,990	-$895,839
Jobs	32.0	39.2	7.1	33.8	1.8	0.0	-32.0	19.6	-12.4	16.9	-15.1
South Puget Sound Subregion[2]											
Hatchery Operations[4]											
Personal Income	$868,856	$1,129,579	$260,723	$1,129,579	$260,723	$1,129,579	$260,723	$1,129,579	$260,723	$1,129,579	$260,723
Jobs	18.1	21.9	3.8	21.9	3.8	21.9	3.8	21.9	3.8	21.9	3.8
Commercial Fisheries											
Personal Income	$1,432,349	$1,625,942	$193,593	$1,480,735	$48,385	$0	-$1,432,349	$812,971	-$619,378	$740,367	-$691,982
Jobs	18.1	20.6	2.5	18.7	0.6	0.0	-18.1	10.3	-7.8	9.4	-8.7
Recreational Fisheries											
Personal Income	$5,346,144	$6,356,887	$1,010,743	$5,598,877	$252,732	$0	-$5,346,144	$3,178,443	-$2,167,701	$2,799,438	-$2,546,706
Jobs	72.1	85.9	13.7	75.6	3.4	0.0	-72.1	42.9	-29.2	37.8	-34.3
Strait of Juan de Fuca Subregion[3]											
Commercial Fisheries											
Personal Income	$27,924	$32,068	$4,144	$28,919	$995	$0	-$27,924	$16,034	-$11,890	$14,459	-$13,464
Jobs	0.7	0.8	0.1	0.7	0.0	0.0	-0.7	0.4	-0.3	0.3	-0.3

Table 44. Personal income and jobs resulting from hatchery operations and commercial and recreational fisheries supported by salmon and steelhead hatchery programs in the Duwamish-Green River Basin under the alternatives, continued.

		Alternative 1 and Alternative 2						**Alternative 4**			
		Without Fish Passage at Howard Hanson Dam		**With Fish Passage at Howard Hanson Dam**		**Alternative 3**		**Without Fish Passage at Howard Hanson Dam**		**With Fish Passage at Howard Hanson Dam**	
Subregion / County of Landings[1]	**Existing Conditions Number**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**	**Number**	**Change from Existing Conditions**
Recreational Fisheries											
Personal Income	$2,789,747	$3,480,660	$690,913	$2,962,521	$172,775	$0	-$2,789,747	$1,740,330	-$1,049,417	$1,481,261	-$1,308,486
Jobs	67.0	83.6	16.6	71.2	4.1	0.0	-67.0	41.8	-25.2	35.6	-31.4
Puget Sound Total											
Hatchery Operations											
Personal Income	$868,856	$1,129,579	$260,723	$1,129,579	$260,723	$1,129,579	$260,723	$1,129,579	$260,723	$1,129,579	$260,723
Jobs	18.1	21.9	3.8	21.9	3.8	21.9	3.8	21.9	3.8	21.9	3.8
Commercial Fisheries											
Personal Income	$1,468,133	$1,666,269	$198,136	$1,517,503	$49,369	$0	-$1,468,133	$833,135	-$634,999	$758,751	-$709,382
Jobs	18.9	21.5	2.6	19.6	0.6	0.0	-18.9	10.7	-8.2	9.8	-9.2
Recreational Fisheries											
Personal Income	$10,037,720	$12,171,033	$2,133,314	$10,573,378	$535,658	$0	-$10,037,720	$6,085,517	-$3,952,203	$5,286,689	-$4,751,031
Jobs	171.2	208.6	37.5	180.6	9.4	0.0	-171.2	104.3	-66.8	90.3	-80.9

Source: Derived by simulating the Puget Sound economic impact spreadsheet model developed by TCW Economics. Refer to Appendix B, Socioeconomics, for details.

[1] Landings represent harvested fish, typically brought to shore at locations that include ports, marinas, and boat launches. This EIS generally refers to "harvest" rather than "landings."

[2] North Puget Sound subregion includes Whatcom and Snohomish Counties (no effects in Skagit County).

[3] South Puget Sound subregion includes King, Pierce, Thurston, and Kitsap Counties.

[4] Strait of Juan de Fuca subregion includes Clallam and Jefferson Counties.

Notes:

Under Alternative 1 through Alternative 4, it is assumed that there would be no change in annual operating costs at the three existing hatchery facilities, and that the annual operating costs for the three new programs at the FRF would generate the same proportionate numbers of FTEs and personal income as those associated with the three existing facilities. Refer to Appendix B, Socioeconomics, for additional details.

All dollar values are reported in 2015 dollars.

4.5.1.3 Regional and Local Economies

Under Alternative 1, increases in commercial harvest and recreational fishing for salmon and steelhead produced by the new FRF hatchery programs would affect employment and personal income compared to existing conditions. These effects would include not only those directly and indirectly related to commercial harvesting of salmon and steelhead and to trip-related expenditures associated with recreational fishing, but also the indirect effects resulting from hatchery operations (i.e., purchases of supplies and re-spending of wages and salaries). Total economic effects include both the direct and indirect effects to local and regional economies.

Commercial Fisheries: Under Alternative 1, if there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the total number of salmon and steelhead from the hatchery programs harvested commercially Puget Sound-wide would increase 0.4 percent[21] (by 16,822 fish) and the total ex-vessel value would increase 0.6 percent (by $119,555) (Table 42), compared to existing conditions (Table 24). If there is fish passage at the dam and releases of fry occur above the dam, the total number of salmon and steelhead harvested commercially Puget Sound-wide and total ex-vessel value would both increase 0.1 percent (by 4,193 fish and $29,789 in total ex-vessel value) (Table 42), compared to existing conditions (Table 24).

Under Alternative 1, if there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the total number of salmon and steelhead from the hatchery programs harvested commercially Puget Sound-wide would increase the total number of jobs by 0.4 percent (by 2.6 jobs), and total personal income would increase 0.6 percent (by $198,136) (Table 44) compared to existing conditions (Table 24). If there is fish passage at the dam and releases of fry occur above the dam, commercial fishing associated with the hatchery programs would increase the total number of jobs and personal income by 0.4 percent (by 0.6 job and $49,369 in total personal income) (Table 44) compared to existing conditions (Table 24). More than 95 percent of these effects on economic activity from commercial fishing would likely occur in King County in the South Puget Sound subregion, regardless of FRF release scenario (Table 44).

[21] Percentages are generated by deriving alternative-specific changes, calculated by subtracting values under existing conditions (or for another alternative, as appropriate) from the values of the alternative being compared, and dividing by the corresponding regional value from Table 24 in Subsection 3.5.3, Regional and Local Economies.

Recreational Fisheries: Under Alternative 1, if there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, recreational effort and trip-related expenditures Puget Sound-wide associated with salmon and steelhead from the hatchery programs would increase by 0.7 percent (by 11,446 total recreational trips and $2,012,449 in total trip-related expenditures) (Table 43) compared to existing conditions (Table 24). If there is fish passage at the dam and releases of fry occur above the dam, the recreational effort and trip-related expenditures Puget Sound-wide associated with salmon and steelhead from the hatchery programs would increase 0.2 percent (by 2,874 total trips and $505,310 in total trip-related expenditures) (Table 43) compared to existing conditions (Table 24).

Under Alternative 1, if there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, recreational fishing Puget Sound-wide associated with salmon and steelhead from the hatchery programs would increase the total number of jobs and personal income by about 1.0 percent (by 37.5 jobs and $2,133,314 in total personal income) (Table 44) compared to existing conditions (Table 24). If there is fish passage at the dam and releases of fry occur above the dam, recreational fishing Puget Sound-wide associated with salmon and steelhead from the hatchery programs would increase the total number of jobs and total personal income by about 0.3 percent (by 9.4 jobs and $535,658 in total personal income) (Table 44) compared to existing conditions (Table 24). The largest contribution to these economic effects from recreational fishing would occur in the South Puget Sound subregion, regardless of FRF release scenario (Table 44).

In summary, under Alternative 1, considering all potential socioeconomic effects, the existing and new salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a low positive effect (Table 41) across the socioeconomics analysis area, which would be the same as under existing conditions. This is because, although jobs and economic values would increase under Alternative 1 compared to existing conditions, the impact of the hatchery programs on personal income and jobs from tribal commercial and non-tribal recreational fisheries, income associated with hatchery operations, and contributions to the local and regional economies would accrue primarily in King County and the South Puget Sound subregion. The economic activity generated by the hatchery programs and by affected commercial and recreational fisheries would have a relatively small impact on the overall economy of King County and in the broader Puget Sound region. However, in some of the more remote areas and communities of the Duwamish-Green River Basin in the South Puget Sound subregion, the effect would be greater because some local economies are more economically dependent on the direct and indirect economic effects of the hatchery programs.

4.5.2 Alternative 2 (Proposed Action) – Make a Determination that the Submitted HGMPs Meet the Requirements of the 4(d) Rule

Under Alternative 2, as under Alternative 1, the hatchery programs would operate as proposed in the submitted HGMPs, and the three new FRF hatchery programs would be implemented (Subsection 2.2.2, Alternative 2), which would not occur under existing conditions. Up to 13,993,000 salmon and steelhead would be produced, including 1,550,000 juvenile salmon and steelhead from the three new FRF hatchery programs, compared to existing conditions under which up to 12,443,000 salmon and steelhead would be produced (Table 27). The two release scenarios for juvenile salmon and steelhead at the three new FRF hatchery programs (Table 26) would be the same as under Alternative 1.

4.5.2.1 Fisheries Affected by the Hatchery Programs

Commercial Fisheries: Under Alternative 2, the contribution of the 10 existing and new hatchery programs to commercial fisheries (number of fish harvested and associated ex-vessel value) of salmon and steelhead in Puget Sound waters would increase compared to existing conditions because of the addition of the three new FRF hatchery programs and would be the same as under Alternative 1 (Table 42). This includes the total number of fish harvested and associated ex-vessel values in tribal and non-tribal fisheries, and the distribution of the harvests and associated values within and among subregions. Under Alternative 2, as under existing conditions and Alternative 1, most of the commercial harvest and associated personal income would occur from tribal fisheries in King County (within the South Puget Sound subregion) (Table 42).

Recreational Fisheries: Under Alternative 2, the contribution of the 10 existing and new hatchery programs to recreational fishing (recreational fishing trips and related expenditures) would be the same as under Alternative 1 (Table 43). Most of the recreational fishing trips and expenditures would occur in the South Puget Sound subregion, followed by the Strait of Juan de Fuca and North Puget Sound subregions, which would be the same as under existing conditions and Alternative 1 (Table 43).

4.5.2.2 Hatchery Operations

Under Alternative 2, employment (jobs) and personal income from the operation of the 10 existing and new hatchery programs would be the same as under Alternative 1 and would result in the same number of jobs and personal income (Table 44). Effects associated with the two release scenarios for juvenile salmon and steelhead at the three new FRF hatchery programs (Table 26) would be the same as under Alternative 1. The jobs and personal income associated with hatchery operations would occur almost entirely in the South Puget Sound subregion (Table 44) because that is the location of the Duwamish-Green River Basin where the existing and new hatchery programs would operate.

4.5.2.3 Regional and Local Economies

Under Alternative 2, the effects of the 10 existing and new hatchery programs to regional and local economies from commercial and recreational fishing would be the same as under Alternative 1 (Table 44 and Appendix B, Socioeconomics). These effects would include not only the jobs and personal income directly related to commercial harvesting of salmon and steelhead, trip-related expenditures, personal income, and jobs associated with recreational fishing and hatchery operations, but also the indirect effects resulting from purchases from suppliers to commercial and recreational fishermen and from the re-spending of the income generated by these economic activities. Most of these jobs and income would occur in the South Puget Sound region, which would be the same as under existing conditions and Alternative 1 (Table 44). Effects associated with the two release scenarios for juvenile salmon and steelhead at the three new FRF hatchery programs (Table 26) would be the same as under Alternative 1.

In summary, under Alternative 2, considering all potential socioeconomic effects, the existing and new salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a low positive effect (Table 41) across the socioeconomics analysis area, which would be the same as under existing conditions and Alternative 1. This is because, although jobs and economic values would increase under Alternative 2 compared to existing conditions, the impact of the hatchery programs on personal income and jobs from tribal commercial and non-tribal recreational fisheries, income associated with hatchery operations, and contributions to the local and regional economies would accrue primarily in King County and in the South Puget Sound subregion. The economic activity generated by the hatchery programs and by affected commercial and recreational fisheries would have a relatively small impact on the overall economy of King County in the South Puget Sound subregion and in the broader Puget Sound region. However, in some of the more remote areas and communities of the Duwamish-Green River Basin in the South Puget Sound subregion, the effect would be greater because some local economies are more economically dependent on the direct and indirect economic effects of the hatchery programs.

4.5.3 Alternative 3 (Termination) – Make a Determination that the Submitted HGMPs Do Not Meet the Requirements of the 4(d) Rule

Under Alternative 3, the existing and new hatchery programs would be terminated (Subsection 2.2.3, Alternative 3), and 12,443,000 fewer hatchery-origin salmon and steelhead would be produced by the hatcheries in the Duwamish-Green River Basin relative to existing conditions, and 13,993,000 fewer would be produced than under Alternative 1 and Alternative 2, which include fish from the new FRF hatchery programs (Table 27). Although the hatchery facilities would not produce salmon and steelhead as proposed in the submitted HGMPs, it is assumed that the hatchery facilities would operate for other programs.

4.5.3.1 Fisheries Affected by the Hatchery Programs

Commercial Fisheries: Under Alternative 3, there would be no contribution of salmon and steelhead to commercial fisheries from the 10 proposed HGMPs; therefore, the effect on commercial fisheries (primarily tribal) in the Puget Sound analysis area would be a reduction of 139,292 fish harvested and an associated decrease in ex-vessel value of $885,868 compared to existing conditions (Table 42). Compared to Alternative 1 and Alternative 2, up to 156,114 fewer fish would be harvested, and the associated ex-vessel value would decline by up to $1,005,423 (depending on FRF release scenario) (Table 42). Under Alternative 3, more than 95 percent of these reductions in commercial harvest and associated ex-vessel value would occur in the South Puget Sound subregion and in tribal commercial fisheries (Table 42).

Recreational Fisheries: Under Alternative 3, there would be no contribution of salmon and steelhead from the 10 proposed HGMPs to recreational fisheries; therefore, the effect on recreational fisheries would be a reduction of 53,856 trips with an associated reduction in trip-related expenditures of $9,469,026, compared to existing conditions (Table 43). Compared to Alternative 1 and Alternative 2, there would be up to 65,302 fewer trips and the associated trip-related expenditures would decline by up to $11,281,475 (depending on FRF release scenario) (Table 43). Under Alternative 3, most of the reduction in recreational fishing activity and trip-related expenditures would occur in the South Puget Sound subregion (Table 43).

4.5.3.2 Hatchery Operations

Under Alternative 3, the existing and new hatchery programs associated with the submitted HGMPs would be terminated (Subsection 2.2.3, Alternative 3), and 12,443,000 fewer hatchery-origin salmon and steelhead would be produced by these hatchery programs in the Duwamish-Green River Basin relative to existing conditions, and 13,993,000 fewer fish would be produced by these hatchery programs than under Alternative 1 and Alternative 2. However, Alternative 3 would not result in changes to hatchery operations, because it is assumed that hatcheries would be used for other purposes. As a result, it is assumed that jobs and personal income for existing and new hatchery programs would be the same as under Alternative 1 and Alternative 2, which would entail 21.9 jobs and $1,129,579 in personal income (Table 44). Under Alternative 3, there would 3.8 more jobs and $260,723 more in personal income compared to existing conditions (Table 44), because the FRF hatchery programs do not exist under existing conditions.

4.5.3.3 Regional and Local Economies

Under Alternative 3, there would be no contribution of salmon and steelhead from the 10 proposed HGMPs to commercial and recreational salmon and steelhead fisheries in the regional and local economies because the programs would be terminated, although hatchery operations would continue.

Commercial Fisheries: Under Alternative 3, the total number of salmon and steelhead harvested commercially Puget Sound-wide would decrease 3.2 percent (by 139,292 fish), and the total ex-vessel value would decrease 4.2 percent (by $885,868) (Table 42) compared to existing conditions (Table 24). The total number of jobs would decrease 3.2 percent (by 18.9 jobs), and total personal income would decrease 4.6 percent (by $1,468,133) (Table 44) compared to existing conditions (Table 24).

Under Alternative 3, depending on the FRF release scenario, the total number of salmon and steelhead harvested commercially Puget Sound-wide would decrease 3.2 to 3.5 percent (by 143,485 to 156,114 fish), and the total ex-vessel value would decrease 4.3 to 4.8 percent (by $915,658 to $1,005,423) (Table 42) compared to existing conditions (Table 24). The total number of jobs would decrease 3.3 to 3.6 percent (by 19.6 to 21.5 jobs), and total personal income would decrease 4.8 to 5.2 percent (by $1,517,503 to $1,666,269 (Table 44 and Table 24) compared to Alternative 1 and Alternative 2. Under Alternative 3, more than 80 percent of these reductions would likely occur in the South Puget Sound subregion (Table 44).

Recreational Fisheries: Under Alternative 3, total recreational trips and trip-related expenditures Puget-Sound wide would decrease 3.6 percent (53,865 trips and $9,649,026 in trip-related expenditures) (Table 43), the total number of jobs would decrease 4.8 percent (by 171.2 jobs) (Table 44), and personal income would decrease 4.7 percent (by $10,037,720) (Table 44) compared to existing conditions (Table 24). Under Alternative 3, depending on FRF release scenario, the total number of recreational trips Puget-Sound wide would decrease 3.8 to 4.4 percent (by 56,730 to 65,302 trips), and trip-related expenditures would decrease 3.4 to 4.3 percent (by $9,974,336 to $11,481,475) (Table 43) compared to Alternative 1 and Alternative 2. Additionally, total jobs would decrease 5.1 to 5.9 percent (by 180.6 to 208.6 jobs), and personal income would decrease 4.9 to 5.7 percent (by $10,573,378 to $12,171,033) (Table 44 and Table 24) compared to Alternative 1 and Alternative 2.

Under Alternative 3, more than 80 percent of these reductions would be expected to occur in the South Puget Sound subregion (Table 44).

In summary, under Alternative 3, considering all potential socioeconomic effects, the existing and new salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a low negative effect (Table 41) across the socioeconomics analysis area, compared to a low positive effect under existing conditions, Alternative 1, and Alternative 2. This is because under Alternative 3, commercial harvests and recreational fishing for salmon and steelhead, and associated effects on jobs and personal income, would decrease relative to existing conditions, Alternative 1, and Alternative 2, particularly in King County and the South Puget Sound subregion. There would be no change in jobs and personal income associated with hatchery operations compared to Alternative 1 and Alternative 2; however, jobs and personal income would increase slightly compared to existing conditions, because of the new FRF hatchery programs.

Although jobs and economic values would decrease under Alternative 3 compared to existing conditions, Alternative 1, and Alternative 2, the reductions associated with the hatchery programs to personal income and jobs from tribal commercial and non-tribal recreational fisheries, income associated with hatchery operations, and contributions to the local and regional economies would occur primarily in King County. The loss of economic activity from the hatchery programs and the associated effects on fisheries would represent a relatively small impact on the overall economy of King County in the South Puget Sound subregion and in the broader Puget Sound region. However, in some of the more remote areas and communities of the Duwamish-Green River Basin in the South Puget Sound subregion, the effect would be greater because some local economies are more economically dependent on the direct and indirect economic effects of the hatchery programs.

4.5.4 Alternative 4 (Reduced Production) – Make a Determination that the Revised HGMPs with Reduced Production Levels Meet the Requirements of the 4(d) Rule

Under Alternative 4, production from the existing and new salmon and steelhead hatchery programs would be reduced by 50 percent (Subsection 2.2.4, Alternative 4) compared to Alternative 1 and Alternative 2. Up to 5,446,500 fewer salmon and steelhead would be released from hatcheries in the Duwamish-Green River Basin compared to existing conditions, and up to 6,996,500 fewer salmon and steelhead would be released compared to Alternative 1 and Alternative 2 (Table 27). Under Alternative 4, up to 6,996,500 more salmon and steelhead would be released than under Alternative 3, wherein the hatchery programs would be terminated. Two release scenarios for the new FRF hatchery programs are possible under Alternative 4, as shown in Table 26, depending on whether fish passage is available at Howard Hanson Dam. Although hatchery production under the submitted HGMPs would be reduced 50 percent under Alternative 4, it is assumed that the hatchery facilities would operate as under the other alternatives.

4.5.4.1 Fisheries Affected by the Hatchery Programs

Commercial Fisheries: Under Alternative 4, the contribution of the 10 existing and new hatchery programs to commercial fisheries (number of fish harvested and associated ex-vessel value) would be less than under existing conditions, Alternative 1, and Alternative 2, but would be greater than under Alternative 3, wherein the programs would be terminated (Table 42). The extent of effects on commercial harvest under Alternative 4 would vary somewhat depending on the release scenario for the three new FRF hatchery programs. If there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the commercial harvest of salmon and steelhead would decrease 44 percent (by 61,235 fish) compared to existing conditions and would decrease by 78,057 fish compared to Alternative 1 and Alternative 2 (Table 42). If there is fish passage at the dam and releases of fry occur above the dam, then commercial harvest of salmon and steelhead would decrease 49 percent (by 67,550 fish) compared to existing conditions, and would decrease by 71,743 fish compared to Alternative 1 and Alternative 2 (Table 42). More than 95 percent of the reduction in commercial harvest under Alternative 4 would occur in the South Puget Sound subregion and would mostly affect tribal fisheries (Table 42). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 commercial fisheries harvest would increase by 71,743 fish if there is fish passage at the dam, and by 78,057 fish without fish passage (Table 42).

Under Alternative 4, the effects on the ex-vessel values of commercial salmon and steelhead landings would be proportionately similar to the effects on commercial harvest described above. If there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the ex-vessel value of salmon and steelhead would decrease 43 percent (by $383,157) compared to existing conditions and would decrease $502,711 compared to Alternative 1 and Alternative 2 (Table 42). If there is fish passage at the dam and releases of fry occur above the dam, then the ex-vessel value of salmon and steelhead would decrease 48 percent (by $428,039) compared to existing conditions and would decrease $457,829 compared to Alternative 1 and Alternative 2 (Table 42). Similar to the decreases in commercial harvest under Alternative 1 and Alternative 2, over 90 percent of the ex-vessel value under Alternative 4 would be to tribal fishermen, regardless of FRF release scenario, and about 98 percent of the ex-vessel value would accrue in the South Puget Sound subregion, which would be similar to existing conditions, Alternative 1, and Alternative 2 (Table 42). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 the ex-vessel value would increase $457,829 with fish passage at the dam, and $502,711 without fish passage (Table 42).

Recreational Fisheries: Under Alternative 4, the contribution of the 10 existing and new hatchery programs to recreational fishing (recreational fishing trips and related expenditures) would be less than under Alternative 1 and Alternative 2, but greater than under Alternative 3 wherein the hatchery programs would be terminated (Table 43). The extent of effects to recreational fishing effort under Alternative 4 would vary somewhat depending on the release scenario for the three new FRF hatchery programs. If there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the number of recreational fishing trips for salmon and steelhead would decrease 39 percent (by 21,205 trips) compared to existing conditions and would decrease by 32,651 trips compared to Alternative 1 and Alternative 2 (Table 43). If there is fish passage at the dam and releases of fry occur above the dam, then the number of recreational fishing trips for salmon and steelhead would decrease 47 percent (by 25,491 trips) compared to existing conditions and would decrease by 28,365 trips compared to Alternative 1 and Alternative 2 (Table 43). Of the decreases in recreational fishing trips, 54 percent of the trips would occur in the South Puget Sound subregion, 27 percent in the Strait of Juan de Fuca subregion, and 19 percent in the North Puget Sound subregion, regardless of release scenario (Table 43). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 recreational trips would increase by 28,365 trips with fish passage at the dam, and by 32,651 trips without fish passage (Table 43).

Under Alternative 4, the effects on trip-related expenditures from recreational fishing would be proportionately similar to those described above for recreational fishing trips. If there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, trip-related expenditures would decrease 39 percent (by $3,728,288) compared to existing conditions and would decrease 50 percent (by $5,740,738) compared to Alternative 1 and Alternative 2 (Table 43). If there is fish passage at the dam and releases of fry occur above the dam, then trip-related expenditures would decrease 47 percent (by $4,481,858) compared to existing conditions and would decrease 50 percent (by $4,987,168) compared to Alternative 1 and Alternative 2 (Table 43). Under Alternative 4, the distribution of the increase in trip-related expenditures among subregions would be similar to recreational fishing trips, with 53 percent of the trip-related expenditures occurring in the South Puget Sound subregion, 28 percent in the Strait of Juan de Fuca subregion, and 19 percent in the

North Puget Sound subregion, regardless of release scenario (Table 43). Under Alternative 4, most of the reduction in recreational fishing activity and trip-related expenditures would occur in the South Puget Sound (Table 43). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 trip-related expenditures would increase by $4,987,168 with fish passage at the dam, and $5,740,738 without fish passage (Table 43).

4.5.4.2 Hatchery Operations

Although hatchery production under the submitted HGMPs would be reduced 50 percent under Alternative 4, it is assumed that the hatchery facilities would operate as under the other alternatives. Under Alternative 4, jobs and personal income for existing and new hatchery programs would be the same as under Alternative 1, Alternative 2, and Alternative 3, which would entail 21.9 jobs and $1,129,579 in personal income (Table 44). Under Alternative 4, there would be 3.8 more jobs and $260,723 more in personal income compared to existing conditions (regardless of FRF release scenario) (Table 44) because the new FRF hatchery programs do not exist under existing conditions.

4.5.4.3 Regional and Local Economies

Under Alternative 4, the direct and indirect contributions of the 10 existing and new hatchery programs to regional and local economies from commercial and recreational fishing (personal income and jobs) would be less than under existing conditions, Alternative 1, and Alternative 2, but greater than under Alternative 3 wherein the hatchery programs would be terminated.

Commercial Fisheries: Under Alternative 4, if there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the total number of salmon and steelhead harvested commercially Puget Sound-wide would decrease 1.4 percent (by 61,235 fish), and total ex-vessel value would decrease 1.8 percent (by $383,157) (Table 42) compared to existing conditions (Table 24). Similarly, if there is no fish passage at the dam, the total number of fish harvested commercially Puget Sound-wide would decrease 1.8 percent (by 78,057 fish), and total ex-vessel value would decrease by 2.4 percent ($502,711) (Table 42) compared to Alternative 1 and Alternative 2 (Table 24). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 total harvest would increase by 78,057 fish and ex-vessel value would increase $502,711 with no fish passage at the dam (Table 42). If there is fish passage at the dam and releases of fry occur above the dam, the total number of salmon and steelhead harvested commercially Puget Sound-wide would decrease 1.5 percent (by 67,550 fish), and total ex-vessel value would decrease 1.8 percent (by $428,039) (Table 42) compared to existing conditions (Table 24). Similarly, if there is fish passage at the dam, the total number of fish harvested commercially Puget Sound-wide would decrease 1.6 percent (by 71,743 fish), and total ex-vessel value would decrease by 2.2 percent ($457,829) (Table 42) compared to Alternative 1 and Alternative 2 (Table 24). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 total harvest would increase by 71,743 fish, and ex-vessel value would increase $457,829 with fish passage at the dam (Table 42).

Under Alternative 4, if there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the total number of salmon and steelhead from the hatchery programs harvested commercially Puget Sound-wide would decrease the number of jobs by 1.4 percent (by 8.2 jobs), and total personal income would decrease 2.0 percent (by $634,999) (Table 44) compared to existing conditions (Table 24). Similarly, if there is no fish passage at the dam, the number of jobs Puget Sound-wide would decrease 1.8 percent (by 10.7 jobs), and total personal income would decrease by 2.6 percent ($833,135) (Table 44) compared to Alternative 1 and Alternative 2 (Table 24). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 the number of jobs would increase by 10.7 jobs and person income would increase $833,135 with no fish passage at the dam (Table 44). If there is fish passage at the dam and releases of fry occur above the dam, commercial fishing associated with the hatchery programs would decrease the total number of jobs and personal income by 1.5 percent (by 9.2 jobs) and personal income by 2.2 percent (by $709,382) (Table 44) compared to existing conditions (Table 24). Similarly, if there is fish passage at the dam, the total number of jobs Puget Sound-wide would decrease 1.6 percent (by 9.8 jobs), and personal income would decrease by 2.4 percent ($758,751) (Table 44) compared to Alternative 1 and Alternative 2 (Table 24). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 the number of jobs would increase by 9.8 jobs and personal income would increase $758,751 with fish passage at the dam (Table 44). As under Alternative 1 and Alternative 2, more than 95 percent of these effects on economic activity from commercial fishing would be expected to occur in King County in the South Puget Sound subregion, regardless of FRF release scenario (Table 44).

Recreational Fisheries: Under Alternative 4, if there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the total number of recreational trips Puget Sound-wide would decrease 1.4 percent (by 21,205 fish), and trip-related expenditures would decrease 1.4 percent (by $3,728,288) (Table 43) compared to existing conditions (Table 24). Similarly, if there is no fish passage at the dam, the number of recreational trips Puget Sound-wide would decrease 1.8 percent (by 32,651 trips), and trip-related expenditures would decrease by 2.4 percent ($5,740,738) (Table 43) compared to Alternative 1 and Alternative 2 (Table 24). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 the total number of recreational trips would increase by 32,651 trips and trip-related expenditures would increase $5,740,738 with no fish passage at the dam (Table 43). If there is fish passage at the dam and releases of fry occur above the dam, the total number of recreational trips Puget Sound-wide would decrease 1.7 percent (by 25,491 fish), and trip-related expenditures would decrease 1.7 percent (by $4,481,858) (Table 43) compared to existing conditions (Table 24). Similarly, if there is fish passage at the dam, the total number of recreational trips Puget Sound-wide would decrease 1.9 percent (by 28,365 trips), and trip-related expenditures would decrease by 1.9 percent ($4,987,168) (Table 43) compared to Alternative 1 and Alternative 2 (Table 24). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 recreational trips would increase by 28,365 trips, and trip-related expenditures would increase $4,987,168 with fish passage at the dam (Table 43).

Under Alternative 4, if there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the total number of salmon and steelhead from the hatchery programs Puget Sound-wide would decrease the number of jobs by 1.9 percent (by 66.8 jobs), and total personal income would decrease 1.8 percent (by $3,952,203) (Table 44) compared to existing conditions (Table 24). Similarly, if there is no fish passage at the dam, the number of jobs Puget Sound-wide would decrease 3.0 percent (by 104.3 jobs), and personal income would decrease 2.8 percent ($6,085,517) (Table 44) compared to Alternative 1 and Alternative 2 (Table 24). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 the total number of jobs would increase by 104.3 jobs and personal income would increase $6,085,517 with no fish passage at the dam (Table 44). If there is fish passage at the dam and releases of fry occur above the dam, recreational fishing associated with the hatchery programs would decrease the total number of jobs by 2.3 percent (by 80.9 jobs) and personal income by 2.2 percent (by $4,751,031) (Table 44) compared to existing conditions (Table 24). Similarly, if there is fish passage at the dam, the total number of jobs Puget Sound-wide would decrease 2.6 percent (by 90.3 jobs), and person income would decrease 2.5 percent ($5,286,689) (Table 44) compared to Alternative 1 and Alternative 2 (Table 24). Compared to Alternative 3, under which the 10 hatchery programs would be terminated, under Alternative 4 jobs would increase by 90.3 jobs and personal income would increase $5,286,689 with fish passage at the dam (Table 44). Under Alternative 4, more than 80 percent of the reductions would occur in the South Puget Sound subregion (Table 44).

In summary, under Alternative 4, considering all potential socioeconomic effects, the existing and new salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a negligible positive effect (Table 41) across the socioeconomic analysis area, compared to a low positive effect under existing conditions Alternative 1, and Alternative 2, and a low negative effect under Alternative 3. This is because under Alternative 4, commercial harvests and recreational fishing for salmon and steelhead, and associated effects on jobs and personal income, would decrease relative to existing conditions, Alternative 1, and Alternative 2, particularly in King County and the South Puget Sound subregion. There would be no change in jobs and personal income associated with hatchery operations compared to Alternative 1 and Alternative 2; however, jobs and personal income would increase slightly compared to existing conditions because of the new FRF hatchery programs.

Although jobs and economic values would decrease under Alternative 4 compared to existing conditions, Alternative 1, and Alternative 2, the reductions associated with the hatchery programs to personal income and jobs from tribal commercial and non-tribal recreational fisheries, income associated with hatchery operations, and contributions to the local and regional economies would occur primarily in King County. As under Alternative 3, the loss of economic activity from the hatchery programs and the associated effects on fisheries under Alternative 4 would have a relatively small impact on the overall economy of King County in the South Puget Sound subregion and the broader Puget Sound region. However, in some of the more remote areas and communities of the Duwamish-Green River Basin in the South Puget Sound subregion, the effect would be greater because some local economies are more economically dependent on the direct and indirect economic effects of the hatchery programs.

4.6 Environmental Justice

The environmental justice analysis addresses effects from existing and proposed new salmon and steelhead hatchery programs in the Duwamish-Green River Basin under each alternative relative to existing conditions as described in Subsection 3.6, Environmental Justice. The analysis describes effects on the following communities and groups of concern identified in Subsection 3.6, Environmental Justice:

- Communities of Concern (Whatcom, Snohomish, King, Pierce, Clallam, and Jefferson Counties)
- Non-tribal User Groups of Concern (Commercial fishermen landing fish in Whatcom, Snohomish, and King Counties associated with the Ports of Bellingham, Marysville/Everett, and Seattle, respectively)

- Native American Tribes of Concern (Puget Sound treaty tribes, particularly the Muckleshoot Indian Tribe and Suquamish Tribe)

This analysis evaluates the environmental justice effects from the seven existing hatchery programs and the three new FRF hatchery programs. As for other resources, the analysis of the new FRF hatchery programs includes two release scenarios that pertain to whether fish passage is available at Howard Hanson Dam (Chapter 4 [Introduction]) (Table 27).

In summary, considering all potential environmental justice effects from the hatchery programs in the Duwamish-Green River Basin under existing conditions (Subsection 3.6, Environmental Justice), the hatchery programs overall have a moderate positive effect (Table 45) in the environmental justice analysis area. This is primarily because of the substantial economic values from commercial and recreational fishing to communities of concern (especially King County and the South Puget Sound subregion) and the substantial benefits to Native American tribes of concern (especially the Muckleshoot Indian Tribe and Suquamish Tribe) from fishing for ceremonial and subsistence and commercial purposes.

Table 45. Comparative summary of effects on environmental justice under the alternatives.

Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Moderate positive	Moderate positive	Moderate positive	Moderate negative	Moderate positive

4.6.1 Alternative 1 (No Action) – Do Not Make a Determination under the 4(d) Rule

Under Alternative 1, the hatchery programs would operate the same as under existing conditions and produce the same number of juvenile fish, and environmental justice conditions would be as described in Subsection 3.6, Environmental Justice. In addition, the three new FRF hatchery programs would be implemented. Up to 13,993,000 salmon and steelhead would be produced, including the 1,550,000 juvenile salmon and steelhead from the three new FRF hatchery programs, relative to existing conditions, under which 12,443,000 salmon and steelhead would be produced (Table 28).

Two release scenarios for the new FRF hatchery programs are possible under Alternative 1 as shown in Table 27, depending on whether fish passage is available at Howard Hanson Dam. If fish passage is not available at the dam under Alternative 1, all of the juvenile salmon and steelhead produced by the FRF hatchery programs would be released below the dam as subyearlings or yearlings. If fish passage is available, then 1,280,000 of the juveniles produced by the FRF hatchery programs would be released above the dam as subyearlings and fry (Table 27) (at younger life stages and at smaller sizes than yearlings).

Communities of Concern: Under Alternative 1, in all three subregions in which the six communities of concern are located, the contributions from the 10 existing and new hatchery programs to commercial harvest, recreational fishing trips and related expenditures, and jobs and personal income related to the hatchery programs would marginally increase compared to existing conditions (Table 42, Table 43, and Table 44) because of the addition of the three new FRF hatchery programs. The increases would occur primarily in King County and the South Puget Sound subregion, and would be similar under either FRF release scenario (Table 42, Table 43, and Table 44).

Under Alternative 1, compared to existing conditions, a total of up to 16,822 more fish would be harvested and associated ex-vessel values would increase by up to (depending on FRF release scenario) $119,555 (Table 42), up to 11,446 more recreational fishing trips and $2,012,449 in trip-related expenditures would accrue (Table 43), up to 2.6 commercial fishing-related jobs and 37.5 recreational fishing-related jobs would be accrue, and up to $198,136 commercial fishing-related and $2,133,314 recreational fishing-related personal income would be added to the regional economy (Table 44). Increases in these economic values from commercial and recreational fishing to communities of concern would be greatest in King County and the South Puget Sound subregion.

Non-tribal User Groups of Concern: Under Alternative 1, the contribution of the 10 existing and new hatchery programs to landings by non-tribal commercial fishermen at 3 ports in the North Puget Sound and South Puget Sound subregions (representing non-tribal user groups of concern) (Table 22) would increase catch and ex-vessel values (Table 42) to a limited extent compared to existing conditions, because of the addition of the three new FRF hatchery programs. Under Alternative 1, compared to existing conditions, non-tribal user groups of concern would harvest a total of up to (depending on FRF release scenario) 277 more fish and associated ex-vessel values would increase up to $1,775 (Table 42). Effects from elimination of these economic values to non-tribal user groups of concern would be greatest in King County and the South Puget Sound subregion. The increases would occur primarily in King County, and would be similar under either FRF release scenario (Table 42).

Native American Tribes of Concern: Under Alternative 1, the contribution of the 10 existing and new hatchery programs to tribal ceremonial and subsistence uses, tribal commercial fisheries (Table 42), and economic values from tribal hatchery operations (Table 44) would increase compared to existing conditions, because of the addition of the three new FRF hatchery programs.

Under Alternative 1, increases in hatchery production would not be expected to change harvests for tribal ceremonial and subsistence uses compared to existing conditions because tribal members customarily meet their ceremonial and subsistence needs as a priority over commercial sales (Subsection 3.4.2.2, Ceremonial and Subsistence Uses, in the PS Hatcheries DEIS [NMFS 2014a]). However, for those tribes who believe that abundances of fish under existing conditions are inadequate to meet their subsistence needs, increases in numbers of salmon and steelhead available for harvest under Alternative 1 would increase the amount available for subsistence harvest.

Under Alternative 1, if there is no fish passage at Howard Hanson Dam and all releases of subyearling or yearling fish occur below the dam, the tribal commercial harvest of salmon and steelhead would be 143,182 fish, an increase of 16,545 fish, and ex-vessel value would be $939,419, an increase of $112,780 (both increases of 12 percent), compared to existing conditions (Table 42). If there is fish passage at the dam and releases of fry occur above the dam, then tribal commercial harvest of salmon and steelhead would be 130,761 fish, an increase of 4,124 fish, and ex-vessel value would be $850,991, an increase of $29,352 (both increases of 3 percent), compared to existing conditions (Table 42). Increases in tribal commercial harvest under Alternative 1 would likely be greatest for the Muckleshoot Indian Tribe and Suquamish Tribe, whose fisheries are most directly associated with the Duwamish-Green River Basin.

Under Alternative 1, the new FRF (which does not occur under existing conditions) would be implemented, which would provide additional jobs and associated personal income for the Muckleshoot Indian Tribe in addition to jobs and income associated with the Keta Creek Complex, which it and the Suquamish Tribe operate under existing conditions.

In summary, under Alternative 1, considering all potential environmental justice effects, the existing and new hatchery programs in the Duwamish-Green River Basin overall would have a moderate positive effect (Table 43) in the environmental justice analysis area, which would be the same as under existing conditions. Although the number of fish available to communities of concern, non-tribal user groups of concern, and Native American tribes of concern would increase, the increases would be insufficient to increase the effect level for the analysis area overall. However, the greatest effects would be the substantial economic values from commercial and recreational fishing to communities of concern (especially King County and the South Puget Sound subregion) and substantial benefits to

Native American tribes of concern (especially the Muckleshoot Indian Tribe and Suquamish Tribe) from fishing for ceremonial and subsistence and commercial purposes.

4.6.2 Alternative 2 (Proposed Action) – Make a Determination that the Submitted HGMPs Meet the Requirements of the 4(d) Rule

Under Alternative 2, as under Alternative 1, the hatchery programs would operate as proposed in the submitted HGMPs, and the new FRF would be implemented (Subsection 2.2.2, Alternative 2), which would not occur under existing conditions. Up to 13,993,000 salmon and steelhead would be produced, including 1,550,000 juvenile salmon and steelhead from the three new FRF hatchery programs, relative to existing conditions under which 12,443,000 salmon and steelhead would be produced (Table 28). The two release scenarios for juvenile salmon and steelhead at the three new FRF hatchery programs (Table 27) would be the same as under Alternative 1.

Communities of Concern: Under Alternative 2, in all three subregions in which the six communities of concern are located, the contributions from the 10 existing and new hatchery programs to commercial harvest, recreational fishing trips and related expenditures, and jobs and personal income related to the hatchery programs would marginally increase compared to existing conditions (Table 42 , Table 43, and Table 44) because of the addition of the three new FRF hatchery programs, which would be the same as under Alternative 1. Under Alternative 2, as under Alternative 1, the increases would occur primarily in King County and the South Puget Sound subregion and would be similar under either FRF release scenario (Table 42, Table 43, and Table 44).

Non-tribal User Groups of Concern: Under Alternative 2, the contribution of the 10 existing and new hatchery programs to landings by non-tribal commercial fishermen at three ports in the North Puget Sound and South Puget Sound subregions (representing non-tribal user groups of concern) (Table 23) would increase catch and ex-vessel values (Table 42) to a limited extent compared to existing conditions because of the addition of the three new FRF hatchery programs, which would be same as under Alternative 1. As under Alternative 1, the increases would occur primarily in King County and would be similar under either FRF release scenario (Table 42).

Native American Tribes of Concern: Under Alternative 2, the contribution of the 10 existing and new hatchery programs to tribal ceremonial and subsistence uses, tribal commercial fisheries (Table 42), and economic values from tribal hatchery operations (Table 44) would increase compared to existing conditions because of the addition of the three new FRF hatchery programs, which would the same as under Alternative 1.

Under Alternative 2, as under Alternative 1, increases in hatchery production would not likely change harvests for tribal ceremonial and subsistence uses compared to existing conditions because tribal members customarily meet their ceremonial and subsistence needs as a priority over commercial sales (Subsection 3.4.2.2, Ceremonial and Subsistence Uses, in the PS Hatcheries DEIS [NMFS 2014a]). However, for those tribes who believe that abundances of fish under existing conditions are inadequate to meet their subsistence needs, increases in numbers of salmon and steelhead available for harvest under Alternative 2 would increase the amount available for subsistence harvest, as would occur under Alternative 1.

Under Alternative 2, the contribution of the 10 existing and new hatchery programs to tribal commercial fisheries in terms of the number of fish and ex-vessel values would increase compared to existing conditions because of the addition of the three new FRF hatchery programs, which would be the same as under Alternative 1 (Table 42). Under Alternative 2, the increases associated with the two FRF release scenarios would be the same as under Alternative 1 and would likely be greatest for the Muckleshoot Indian Tribe and Suquamish Tribe, whose fisheries are most directly associated with the Duwamish-Green River Basin.

Under Alternative 2, as under Alternative 1, the new FRF (which does not occur under existing conditions) would be implemented, which would provide additional jobs and associated personal income for the Muckleshoot Indian Tribe in addition to jobs and income associated with the Keta Creek Complex, which the Muckleshoot Indian Tribe and the Suquamish Tribe operate under existing conditions.

In summary, under Alternative 2, considering all potential environmental justice effects, the existing and new hatchery programs in the Duwamish-Green River Basin overall would have a moderate positive effect (Table 43) in the environmental justice analysis area, which would be the same as under existing conditions and Alternative 1. Although the number of fish available to communities of concern, non-tribal user groups of concern, and Native American tribes of concern would increase relative to existing conditions, the increases would be insufficient to increase the effect level for the analysis area overall. However, the greatest effects would be the substantial economic values from commercial and recreational fishing to communities of concern (especially King County and the South Puget Sound subregion) and substantial benefits to Native American tribes of concern (especially the Muckleshoot Indian Tribe and Suquamish Tribe) from fishing for ceremonial and subsistence and commercial purposes.

4.6.3 Alternative 3 (Termination) – Make a Determination that the Submitted HGMPs Do Not Meet Requirements of the 4(d) Rule

Under Alternative 3, the existing and new hatchery programs would be terminated (Subsection 2.2.3, Alternative 3), and 12,443,000 fewer hatchery-origin salmon and steelhead would be produced by the hatcheries in the Duwamish-Green River Basin relative to existing conditions, and 13,993,000 fewer would be produced than under Alternative 1 and Alternative 2, which would include fish from the new FRF hatchery programs (Table 28). Although the hatchery facilities would not produce salmon and steelhead as proposed in the submitted HGMPs, it is assumed that the hatchery facilities would operate for other programs.

Communities of Concern: Under Alternative 3, there would be no contribution to the three subregions in which the six communities of concern are located from the 10 existing and new hatchery programs; therefore, the effects on commercial harvest, recreational fishing trips and related expenditures, and jobs and personal income would be substantial compared to existing conditions, Alternative 1, and Alternative 2 (Table 42, Table 43, and Table 44).

Under Alternative 3, compared to existing conditions, a total of 139,292 fewer fish would be harvested and associated ex-vessel values would decrease by up to $885,868 (Table 42), up to 53,856 fewer recreational fishing trips and $9,469,026 in trip-related expenditures would be generated (Table 43), up to 18.9 commercial fishing-related and 171.2 recreational fishing-related jobs, and up to $1,468,133 in commercial fishing-related and $10,037,720 in recreational fishing-related personal income would be lost to the regional economy (Table 44). Decreases in these economic values from commercial and recreational fishing to communities of concern would be greatest in King County and the South Puget Sound subregion.

Under Alternative 3, compared to Alternative 1 and Alternative 2, a total of up to (depending on FRF release scenario) 156,114 fewer fish would be harvested and associated ex-vessel values would decrease by $1,005,423 (Table 42), 65,302 fewer recreational fishing trips and $11,281,475 fewer trip-related expenditures would accrue (Table 43), 21.5 commercial fishing-related jobs and 208.6 recreational fishing-related jobs would be lost, and $1,666,269 commercial fishing-related and $12,171,033 recreational fishing-related personal income would be lost to the regional economy (Table 44).

Non-tribal User Groups of Concern: Under Alternative 3, there would be no contribution from the 10 existing and new hatchery programs to landings by non-tribal commercial fishermen at three ports in the North Puget Sound and South Puget Sound subregions (representing non-tribal user groups of concern) (Table 23); therefore, ex-vessel values and personal income to non-tribal commercial fishermen in these subregions would be reduced compared to existing conditions, Alternative 1, and Alternative 2 (Table 42).

Under Alternative 3, compared to existing conditions, non-tribal user groups of concern would harvest a total of 12,665 fewer fish and associated ex-vessel values would decrease $64,229 (Table 42). Under Alternative 3, compared to Alternative 1 and Alternative 2, a total of up to (depending on FRF release scenario) 12,932 fewer fish would be harvested and associated ex-vessel values would decrease by up to $66,004 (Table 42). Effects from elimination of these economic values to non-tribal user groups of concern would be greatest in King County and the South Puget Sound subregion.

Native American Tribes of Concern: Under Alternative 3, there would be no contribution from the 10 existing and new hatchery programs to tribal ceremonial and subsistence uses or tribal commercial fisheries (Table 42); therefore, the effects on tribal cultural and economic values would be substantial compared to existing conditions, Alternative 1, and Alternative 2, especially for the Muckleshoot Indian Tribe and Suquamish Tribe, whose fisheries are most directly associated with the Duwamish-Green River Basin. Although tribal hatchery facilities would not produce salmon and steelhead as proposed in the submitted HGMPs, it is assumed that the hatchery facilities would operate for other programs, and there would be no change in tribal jobs or funding the tribes receive for administration and other operational needs.

Under Alternative 3, compared to existing conditions, tribal commercial fisheries would harvest a total of 126,637 fewer fish and associated ex-vessel values would decrease $821,639 (Table 42). Under Alternative 3, compared to Alternative 1 and Alternative 2, a total of up to (depending on FRF release scenario) 143,182 fewer fish would be harvested and associated ex-vessel values would decrease by up to $939,419 (Table 42).

In summary, under Alternative 3, considering all potential environmental justice effects, termination of the existing and new hatchery programs in the Duwamish-Green River Basin overall would have a moderate negative effect (Table 43) in the environmental justice analysis area overall, because the number of fish available to communities of concern, non-tribal user groups of concern (non-tribal commercial fishermen), and Native American tribes of concern would substantially decrease in contrast to existing conditions, Alternative 1, and Alternative 2, which would all have a moderate positive environmental justice effect. Negative effects would be greatest due to decreases in economic and cultural values associated with commercial and recreational fishing to communities of concern (especially King County and the South Puget Sound subregion) and due to substantial losses to Native American tribes of concern (especially the Muckleshoot Indian Tribe and Suquamish Tribe) from fishing for ceremonial and subsistence and commercial purposes.

4.6.4 Alternative 4 (Reduced Production) – Make a Determination that the Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

Under Alternative 4, production from the existing and new salmon and steelhead hatchery programs would be reduced by 50 percent (Subsection 2.2.4, Alternative 4) compared to Alternative 1 and Alternative 2. Up to 5,446,500 fewer salmon and steelhead would be released from hatcheries in the Duwamish-Green River Basin compared to existing conditions, and up to 6,996,500 fewer salmon and steelhead would be released compared to Alternative 1 and Alternative 2 (Table 28). Under Alternative 4, up to 6,996,500 more salmon and steelhead would be released than under Alternative 3, wherein the hatchery programs would be terminated. Two release scenarios for the new FRF hatchery programs are possible under Alternative 4, as shown in Table 27, depending on whether fish passage is available at Howard Hanson Dam. Although hatchery production under the submitted HGMPs would be reduced 50 percent under Alternative 4, it is assumed that the hatchery facilities would operate as under the other alternatives resulting in no change in hatchery employment and associated personal income.

Communities of Concern: Under Alternative 4, the contributions from the 10 existing and new hatchery programs to commercial harvest, recreational fishing trips and related expenditures, and jobs and personal income related to the hatchery programs would be less than under existing conditions, Alternative 1, and Alternative 2, but would be greater than under Alternative 3, wherein the programs would be terminated (Table 42, Table 43, and Table 44). The decreases under Alternative 4 would occur primarily within King County and the South Puget Sound subregion, and would be similar under either FRF release scenario.

Under Alternative 4, compared to existing conditions, a total of up to (depending on FRF release scenario) 61,256 fewer fish would be harvested and associated ex-vessel values would decrease by $396,143 (Table 42), up to 25,491 fewer recreational fishing trips and $4,481,858 fewer trip-related expenditures would accrue (Table 43), up to 9.2 commercial fishing-related jobs and 80.9 recreational fishing-related jobs would be lost, and up to $709,382 commercial fishing-related and $4,751,031 recreational fishing-related personal income would be lost to the regional economy (Table 44).

Non-tribal User Groups of Concern: Under Alternative 4, the contributions from the 10 existing and new hatchery programs to landings by non-tribal commercial fishermen at three ports in the North Puget Sound and South Puget Sound subregions (representing non-tribal user groups of concern) (Table 23) would be less than under existing conditions, Alternative 1, and Alternative 2, but would be greater than under Alternative 3, wherein the programs would be terminated (Table 42). Under Alternative 4, compared to existing conditions, a total of up to (depending on FRF release scenario) 6,293 fewer fish would be harvested in non-tribal commercial fisheries and associated ex-vessel values would decrease by $31,896 (Table 42). Under Alternative 4, compared to Alternative 1 and Alternative 2, a total of up to (depending on FRF release scenario) 6,466 fewer fish would be harvested and associated ex-vessel values would decrease by up to $33,002 (Table 42). Effects on non-tribal user groups of concern under Alternative 4 would be greatest in King County and the South Puget Sound subregion.

Native American Tribes of Concern: Under Alternative 4, the contribution of the 10 existing and new hatchery programs to tribal ceremonial and subsistence uses and tribal commercial fisheries (Table 42), would be less than under existing conditions, Alternative 1, and Alternative 2, but would be greater than under Alternative 3, wherein the programs would be terminated.

Under Alternative 4, decreases in hatchery production would not be expected to change harvests for tribal ceremonial and subsistence uses compared to existing conditions, Alternative 1, or Alternative 2, because tribal members customarily meet their ceremonial and subsistence needs as a priority over commercial sales (Subsection 3.4.2.2, Ceremonial and Subsistence Uses, in the PS Hatcheries DEIS [NMFS 2014a]). However, for those tribes who believe that abundances of fish under existing conditions are inadequate to meet their subsistence needs, decreases in numbers of salmon and steelhead available for harvest under Alternative 4 would further decrease the amount available for subsistence harvest.

Compared to existing conditions, Alternative 1, and Alternative 2, the effects on tribal cultural and economic values would be substantial, especially for the Muckleshoot Indian Tribe and Suquamish Tribe, whose fisheries are most directly associated with the Duwamish-Green River Basin. Although tribal hatchery facilities would not produce as many salmon and steelhead as proposed in the submitted HGMPs, it is assumed that the hatchery facilities would operate for other programs, and there would be no change in tribal jobs or funding the tribes receive for administration and other operational needs.

Under Alternative 4, compared to existing conditions, tribal commercial fisheries would harvest a total of up to (depending on FRF release scenario) 61,256 fewer fish, and associated ex-vessel values would decrease $396,143 (Table 42). Under Alternative 4, compared to Alternative 1 and Alternative 2, a total of up to 71,591 fewer fish would be harvested, and associated ex-vessel values would decrease by up to $469,709 (Table 42).

In summary, under Alternative 4, considering all potential environmental justice effects, the existing and new salmon and steelhead hatchery programs in the Duwamish-Green River Basin overall would have a moderate positive effect (Table 43) in the environmental justice analysis area, which would be the same as under existing conditions, Alternative 1, and Alternative 2, and in contrast to a moderate negative effect under Alternative 3, wherein the programs would be terminated. This is because, although economic and cultural values would decrease under Alternative 4 compared to existing conditions, Alternative 1, and Alternative 2, tribal fisheries for ceremonial and subsistence, and commercial purposes have a high value to Indian tribes with treaty-reserved fishing rights.

4.7 Human Health

As described in Subsection 3.7, Human Health, in this EIS, and in Subsection 3.7, Human Heath, and Subsection 4.7, Human Health, in the PS Hatcheries DEIS (NMFS 2014a), which are incorporated by reference, operation of hatchery facilities may affect human health from chemicals used at hatchery facilities, procedures used in handling of those chemicals, occurrence of potentially toxic contaminants in hatchery-origin fish, and potential diseases transmitted to people from handling hatchery-origin fish. Use of chemicals may include disinfectants, therapeutics, anesthetics, pesticides and herbicides, and feed additives (Appendix K, Chemicals Used in Hatchery Operations, in the PS Hatcheries DEIS [NMFS 2014a]). Although fish are generally considered to be nutritionally beneficial, concerns may exist when fish contain toxic contaminants that pose health risks to people. However, contaminants accumulated during hatchery rearing are expected to contribute very little to concentrations of contaminants in returning adult salmon and steelhead because concentrations acquired only during the relatively short juvenile rearing period would be diluted as the fish grow larger to adulthood (Subsection 3.7.2, Toxic Contaminants in Hatchery-origin Fish, in the PS Hatcheries DEIS [NMFS 2014a]). A number of pathogens (parasites, viruses, and bacteria) are potentially harmful to human health and can be transmitted to people if proper safety procedures are not followed (i.e., protective clothing, fish handling, and proper food preparation).

As described in Subsection 3.7, Human Health, and Appendix K, Chemicals Used in Hatchery Operations, in the PS Hatcheries DEIS (NMFS 2014a), which are incorporated by reference into this EIS, effects from operation of salmon and steelhead hatchery programs in the Puget Sound area, including the Duwamish-Green River Basin, on human health are not substantial. Similar results were found in other NEPA analyses of hatchery programs in Puget Sound river basins (Subsection 3.9, Human Health and Safety, in the Elwha FSEA [NMFS 2014b]; Subsection 3.9, Human Health and Safety, in the Dungeness Hatcheries FEA [NMFS 2016a]; and Subsection 3.9, Human Health and Safety, in the Hood Canal Hatcheries FEA [NMFS 2016b]). The effects of hatchery operations on human health are not substantial primarily because use of therapeutics is minimal and in compliance with label requirements; hatchery operations comply with worker safety programs, rules, and regulations; and personal protective equipment is used that limits the spread of pathogens. Toxic contaminants accumulated by individual hatchery-origin fish before and after release would be the same under all alternatives because the accumulation of toxic contaminants would not be dependent on changes in hatchery production levels.

In summary, considering all effects on human health from the hatchery programs under existing conditions, the hatchery programs have a negligible negative effect on human health in the Duwamish-Green River Basin, primarily because hatchery operations comply with worker safety programs, rules, and regulations; the use of therapeutics is minimal and in compliance with label requirements; and personal protective equipment is used that limits the spread of pathogens (Table 46).

Table 46. Comparative summary of human health effects under the alternatives.

Existing Conditions	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Termination)	Alternative 4 (Reduced Production)
Negligible negative	Negligible negative	Negligible negative	Negligible positive	Negligible negative

Alternative 1: Under Alternative 1, the effects from hatchery operations on human health associated with the seven existing hatchery programs would be the same as under existing conditions (Subsection 3.7, Human Health), which would release up to 12,443,000 salmon and steelhead annually (Table 28). Also under Alternative 1, in contrast to existing conditions, an additional 1,550,000 salmon and steelhead juveniles would be released from the three new FRF hatchery programs (Table 28). The amount and types of chemicals used in the three new hatchery facilities, including disinfectants, therapeutics, anesthetics, pesticides and herbicides, feed additives, and miscellaneous chemicals would

be the same as under existing conditions. All safety precautions and Federal and state programs, rules, and regulations would continue to be followed so that these chemicals would not be considered hazardous to human health.

In summary, under Alternative 1, considering all potential human health risks, the salmon and steelhead hatchery programs overall would have a negligible negative effect on human health in the Duwamish-Green River Basin (Table 46), primarily because hatchery operations would comply with worker safety programs, rules, and regulations; the use of therapeutics would be minimal and in compliance with label requirements; and personal protective equipment would be used that limits the spread of pathogens.

Alternative 2: Under Alternative 2, all 10 of the hatchery programs would operate as under Alternative 1. Releases of hatchery-origin salmon and steelhead from the programs would total 13,993,000 juveniles, which would be same as under Alternative 1 (Table 28). Human health effects would be the same as under Alternative 1.

In summary, under Alternative 2, considering all potential human health risks, the salmon and steelhead hatchery programs overall would have a negligible negative effect on human health in the Duwamish-Green River Basin (Table 46), primarily because hatchery operations would comply with worker safety programs, rules, and regulations; the use of therapeutics would be minimal and in compliance with label requirements; and personal protective equipment would be used that limits the spread of pathogens, which would be the same as under existing conditions and Alternative 1.

Alternative 3: Under Alternative 3, all hatchery programs in the Duwamish-Green River Basin would be terminated and would not release 12,443,000 salmon and steelhead as under existing conditions, and the additional 1,550,000 salmon and steelhead juveniles produced by the new FRF hatchery programs under Alternative 1 and Alternative 2 would not be released (Table 28). Therefore, all human health effects associated with the ongoing and proposed new programs would be eliminated relative to existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 3, considering all potential human health risks, the elimination of the salmon and steelhead programs overall would have a negligible positive disease effect on human health in the Duwamish-Green River Basin (Table 46) because all human health effects from the hatchery programs would be eliminated, relative to existing conditions, Alternative 1, and Alternative 2.

Alternative 4: Under Alternative 4, production from hatchery programs in the Duwamish-Green River Basin would be reduced 50 percent relative to Alternative 1 and Alternative 2, and the hatchery programs would release up to 6,996,500 fewer hatchery-origin salmon and steelhead from ongoing and proposed new FRF hatchery programs than under existing conditions, Alternative 1 and Alternative 2 (Table 28). Although fewer fish would be produced under Alternative 4 compared to existing conditions, Alternative 1, and Alternative 2, human health effects would be the same as under existing conditions, Alternative 1, and Alternative 2.

In summary, under Alternative 4, considering all potential human health effects, the salmon and steelhead hatchery programs overall would have a negligible negative disease effect on human health in the Duwamish-Green River Basin (Table 46), which would be the same as under existing conditions, Alternative 1, and Alternative 2, primarily because hatchery operations would comply with worker safety programs, rules, and regulations; the use of therapeutics would be minimal and in compliance with label requirements; and personal protective equipment would be used that limits the spread of pathogens. In comparison to Alternative 3 (negligible positive), human health effects under Alternative 4 would be increased because the hatchery programs would be terminated under Alternative 3, thereby eliminating the potential for human health effects.

4.8 Summary of Resource Effects

This subsection provides a summary of potential direct and indirect environmental effects on the physical, biological, and human resources that are associated with the alternatives. Cumulative effects associated with the alternatives are described in Chapter 5, Cumulative Effects. Each subsection listed below describes potential effects on a specific resource topic; each resource topic is described in a corresponding main subsection in Chapter 3, Affected Environment. The specific order of the resource effects summarized in this subsection is:

- Water Quantity and Quality (Subsection 4.1)
- Salmon and Steelhead (Subsection 4.2)
- Other Fish Species (Subsection 4.3)
- Wildlife – Southern Resident Killer Whale (Subsection 4.4)
- Socioeconomics (Subsection 4.5)
- Environmental Justice (Subsection 4.6)
- Human Health (Subsection 4.7)

Table 47 summarizes predicted effects from implementation of the No-action Alternative (Alternative 1) and the action alternatives (Alternative 2 through Alternative 4). This table summarizes the detailed resource discussions in Subsection 4.1, Water Quantity and Quality, through Subsection 4.7, Human Health. Refer to those subsections for context and background to support conclusions stated in Table 46. No preferred alternative has been identified in this draft EIS.

Table 47. Summary of environmental consequences by resource and alternative.

Resource	Alternative 1 (No Action)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Termination)	Alternative 4[1] (Reduced Production)
Water Quantity and Quality	The hatchery programs would have a low negative effect on water quantity, primarily because water use would generally be non-consumptive and limited by water right permits, and because all surface water diverted would be returned near the points of withdrawal after it circulates through the hatchery facilities.	Same as Alternative 1.	Effects on water quantity would be the same as Alternative 1, because although the proposed salmon and steelhead programs would be terminated, the operators would exercise their water rights for the hatchery facilities.	Although hatchery production would be reduced 50 percent, effects on water quantity would be the same as Alternative 1.
	The hatchery programs would have a negligible negative effect on water quality primarily because hatchery operations are limited by NPDES permits and would not be expected to contribute substantially to water quality impairments in the basin.	Same as Alternative 1.	The hatchery programs would have a negligible positive effect on water quality because the proposed hatchery programs would be terminated.	Although hatchery production would be reduced 50 percent, effects on water quality would be the same as Alternative 1.
Salmon and Steelhead	The hatchery programs would generally have negligible to high negative genetics, competition, predation, facility operations, masking, incidental fishing, and disease transfer effects; and negligible to moderate positive population viability and nutrient cycling effects depending on the affected species.	Same as Alternative 1.	Because the hatchery programs would be terminated, all negative and positive effects on salmon and steelhead would be eliminated.	Because hatchery production would be reduced 50 percent, the negative genetics, competition, predation, facility operations, masking, incidental fishing, and disease transfer effects and the positive population viability and nutrient cycling effects would be reduced.

Table 47. Summary of environmental consequences by resource and alternative (continued).

Resource	Alternative 1 (No Action)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Termination)	Alternative 4[1] (Reduced Production)
Other Fish Species	The hatchery programs would have negligible negative or negligible positive effects on other fish species, depending on whether the hatchery-origin fish compete with or prey on the species.	Same as Alternative 1.	Because the hatchery programs would be terminated, all negative and positive effects on other fish species as competitors and predators would be eliminated.	Same as Alternative 1, because hatchery production would be reduced 50 percent and the negative effects on other fish species that compete with hatchery-origin fish, and the positive effects on other fish species benefit from the hatchery-origin fish as a food source would be reduced.
Wildlife – Southern Resident killer whale	The hatchery programs would have a negligible positive effect by providing a source of prey for Southern Resident killer whales.	Same as Alternative 1.	Because the hatchery programs would be terminated, there would be a negligible negative effect on Southern Resident killer whales because a source of prey would be eliminated.	Same as Alternative 1, because hatchery production would be reduced 50 percent and the positive effect to Southern Resident killer whales from the hatchery-origin fish as source of prey would be reduced.

Table 47. Summary of environmental consequences by resource and alternative (continued).

Resource	Alternative 1 (No Action)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Termination)	Alternative 4[1] (Reduced Production)
Socioeconomics	The hatchery programs would have a low positive effect on socioeconomics because personal income and jobs from tribal commercial and non-tribal recreational fisheries, income associated with hatchery operations, and contributions to the local and regional economies, would accrue primarily in King County in the South Puget Sound subregion. In addition, the economic activity and fisheries effects from the hatchery programs would have a relatively small impact on the overall economy of King County and in the broader Puget Sound region. In some of the more remote areas of the river basin and the South Puget Sound subregion more economically dependent on income derived the hatchery programs, effects would likel be greater.	Same as Alternative 1.	Because the hatchery programs would be terminated, there would be a low negative effect on socioeconomics because all commercial and recreational fishing, jobs, and personal income associated with the hatchery programs would be eliminated.	The hatchery programs would have a negligible positive effect on socioeconomics because hatchery production would be reduced 50 percent, resulting in fewer returning adults to be harvested in commercial and recreational fisheries, and contributions to regional and local economies would be less relative to Alternative 1.

Table 47. Summary of environmental consequences by resource and alternative (continued).

Resource	Alternative 1 (No Action)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Termination)	Alternative 4[1] (Reduced Production)
Environmental Justice	The hatchery programs would have a moderate positive effect on environmental justice, primarily because of their economic impact on communities of concern (King County and the South Puget Sound subregion) and benefits to Native American tribes of concern from fishing for ceremonial and subsistence and commercial purposes.	Same as Alternative 1.	Because the hatchery programs would be terminated, there would be a moderate negative effect on environmental justice because all commercial and recreational fishing in communities of concern associated with the hatchery programs would be eliminated. Tribal ceremonial and subsistence fishing would continue.	Same as Alternative 1 because, although hatchery production would be reduced 50 percent, the hatchery programs would substantially benefit fishing by user groups of concern (commercial fishermen) and Native American tribes of concern from fishing for ceremonial and subsistence and commercial purposes.
Human Health	The hatchery programs would have a negligible negative effect on human health, primarily because the hatchery programs would comply with worker safety programs, rules, and regulations; the use of therapeutics would be minimal and in compliance with label requirements; and personal protective equipment would be used that limits the spread of pathogens.	Same as Alternative 1.	Because the hatchery programs would be terminated, there would be a negligible positive effect on human health.	Although hatchery production would be reduced 50 percent, human health effects would be the same as Alternative 1.

[1] Potential differences between the no action and the action alternatives would be due to differences in hatchery production levels.

Chapter 5

5 CUMULATIVE EFFECTS

5.1 Introduction

The NEPA defines cumulative effects as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions” (40 CFR 1508.7). For this EIS, actions analyzed include those similar to the Proposed Action that are hatchery-related and those that are not hatchery-related, including habitat loss and degradation from human development. This chapter discusses the impact on the environment that would result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions.

Chapter 3, Affected Environment, describes the existing conditions (the baseline for analysis in this chapter) for each resource and reflects the effects of past actions and present conditions. Chapter 4, Environmental Consequences, evaluates the direct and indirect effects of the alternatives on each resource’s baseline (existing) conditions. This chapter considers the cumulative effects of each alternative in the context of past actions, present conditions, and reasonably foreseeable future actions and conditions.

5.1.1 Geographic and Temporal Scales

The cumulative effects analysis area includes the project area described in Subsection 1.4, Project and Analysis Areas, and broader Puget Sound area, with particular attention to the freshwater, estuarine, and adjacent nearshore marine areas of the Duwamish-Green River Basin. This cumulative effects analysis area was determined based on the geography, topography, waterways, and natural interactions that occur among the ecosystems present in the Duwamish-Green River Basin and affiliated marine waters, and how hatchery-origin fish associated with the Proposed Action would use the overall area.

The temporal scope of past and present actions for the affected resources encompasses actions that occurred prior to and after Puget Sound salmon and steelhead species became listed under the ESA. This is also the temporal context within which affected resources are described in Chapter 3, Affected Environment, whereby existing conditions are a result of prior and ongoing actions in the project area. The temporal scope for reasonably foreseeable future actions for the affected resources is at least 15 years. The analysis of development and habitat restoration effects in this chapter encompasses approximately three generations of salmon and steelhead (one generation takes about 5 years), which is the number of generations over which changes in response to management actions might reasonably be observed. Climate change is expected to continue to occur over the long term. Thus, the analysis reflects shorter-term effects in relation to the scale of climate change. Considering the timeframe, this cumulative effects analysis provides expected trends, but recognizes that sufficient data are lacking to definitively determine the magnitude of effects.

5.1.2 Chapter Organization

Provided below are known past, present, and future actions from a regional context that have occurred, are occurring, or are reasonably likely to occur within the cumulative effects analysis area. Subsection 5.2, Past Actions, summarizes past actions that affected resources in the cumulative effects analysis area; Subsection 5.3, Present Conditions, describes current overall trends for resources in the area; and Subsection 5.4, Future Actions and Conditions, describes climate change effects and reasonably foreseeable future development, habitat restoration, hatchery production, and fisheries activities and objectives supported by agencies and other non-governmental organizations to restore habitat in the cumulative effects analysis area. Finally, Subsection 5.5, Cumulative Effects by Resource, describes how these past, present, and future actions affect each resource evaluated in this EIS, and specifically focuses on the effects of the alternatives when possible.

5.2 Past Actions

Humans have occupied the shores and islands of Puget Sound for many millennia (Gunther 1950). Before Europeans arrived in the Puget Sound ecosystem, most human inhabitants were hunter-gatherers. They relied on sea life for food, animals for food and warm clothing, and trees for building materials. Indigenous peoples were known to use the waterways of the Salish Sea (Puget Sound, Strait of Juan de Fuca, Strait of Georgia) as trading routes. Fire was used to modify the environment, to clear areas to aid hunting, to promote berry production, and to support the growth of grasses for making nets, baskets, and blankets (Barsh 2003).

In the 1800s, with the arrival of the first Europeans, trapping and logging were initiated on a large scale, which changed the landscape. Washington State became one of the top five producers of timber, and salmon harvest increased by over 2,000 percent compared to harvest before European arrival. As natural resource extraction and the number of people in the area increased, the quality of the Salish Sea ecosystem declined. Most of the old-growth forest was harvested, and much forestland was converted to human-dominated uses, such as agriculture and urban development. The quantity and availability of tidal marsh and other freshwater estuarine ecosystem types declined, floodplains were altered, rivers and streams were channelized, dams were constructed in some river basins, estuaries were filled, shorelines were hardened and/or modified, water and air quality declined, pollution and marine traffic increased, and habitat was lost (Puget Sound Partnership [PSP] 2012). Additionally, hydropower development in the cumulative effects analysis area increased in the early decades of the 20th century, which altered stream courses, backfilled large tracts of land, and prevented fish spawning.

The most substantial factors contributing to habitat degradation in the Duwamish-Green River Basin occurred early in the 20th century: (1) changes in the routing of the Green, White, Cedar, and Black Rivers that resulted in an overall reduction of the Duwamish River draining into Elliott Bay, and (2) filling of the Duwamish River estuary marsh and tidelands to create Seattle’s industrial port (NWIFC 2016). Additionally, in the mid-20th century, streams were drained, channelized, or confined, and forests were converted to agricultural, residential, and commercial/industrial uses. The project area has three primary geographic areas (industrial/urban in the lower river basin, rural and forested in the middle river basin, and forested in the upper river basin [e.g., above Howard Hanson Dam]). Each of these geographic areas has been subject to different levels of human-based disturbances, with disturbances in the lower river basin negatively affecting aquatic/riparian habitat to the greatest extent. In addition, the construction of Howard Hanson Dam in 1961 for flood control purposes, and the City of Tacoma water diversion project to provide a long-term water supply to the City and adjacent communities, blocked fish passage into upstream areas.

As a result of these changes in the Duwamish-Green River Basin, the quantity and availability of tidal marsh and freshwater estuarine ecosystem types declined, floodplains and water flow were altered, rivers and streams were channelized, salmon and steelhead spawning areas were lost in the upper Green River, shorelines were hardened and/or modified, water and air quality declined, pollution and marine traffic increased, and habitat was lost (Green/Duwamish and Central Puget Sound Watershed Water Resource Inventory Area 9 (WRIA 9) Steering Committee 2005). Subsequently, with these land use changes (as occurred elsewhere throughout Puget Sound), the number of aquatic species listed under the ESA increased, as did the presence of non-native invasive species (Quinn 2010).

In response to human-based disturbances in the Duwamish-Green River Basin, restoration efforts have been and continue to be implemented by Federal, state, and local agencies and tribes. These efforts include work to restore water quality; remove toxins released by industrial processes; restore salmon and steelhead fish passage, habitat, and ecosystems; provide for tribal treaty rights; recover listed species; improve fisheries; and protect human and aquatic health. The lower Duwamish River has been designated by EPA as a Superfund site since 2001, which resulted in development of a natural resource damage assessment to determine the extent of injuries to natural resources and develop a restoration plan (NOAA 2013; EPA 2014). The City of Tacoma completed a habitat conservation plan (HCP) under the ESA for their water supply operations (Tacoma Water 2001).

Agencies and Indian tribes involved in supporting the restoration and sustainability of the Duwamish-Green River Basin include NOAA, USFWS, USACE, EPA, U.S. Forest Service, Federal Emergency Management Agency, Muckleshoot Indian Tribe, Suquamish Tribe, Northwest Indian Fisheries Commission (NWIFC), PSP, WDFW, Ecology, Washington State Department of Health, Puget Sound Regional Council (PSRC), Port of Seattle, King County, City of Seattle and other cities within the project area (Tukwila, Renton, Kent, and Auburn), as well as non-profit organizations and businesses (and their associations) that occur along the Duwamish and Green Rivers. Restoration and related studies funded and/or reviewed by these agencies are recognized as providing valuable background information on the Duwamish-Green River Basin and are incorporated by reference in Chapter 3 as relevant to the HGMPs evaluated in this EIS.

Salmon and steelhead have been propagated in hatcheries in Puget Sound river basins since the late 19th century (Puget Sound Treaty Tribes and WDFW 2004). The purpose of early hatchery programs was to support commercial and recreational fisheries as compensation for declining natural-origin fish populations due to overfishing. Over time, fish produced in hatcheries in the Puget Sound area gradually began to be used as mitigation for the negative effects of human development and associated habitat degradation on natural-origin salmon and steelhead survival and productivity.

In the 1970s, the legal framework established by *United States* v. *Washington* (1974) became the primary driver for defining fish production and harvest objectives in watershed and marine areas of Puget Sound.

The Pacific Salmon Treaty between Canada and the United States was finalized March 17, 1985 (Pacific Salmon Commission 1985), to provide a framework for the involved parties to manage salmon stocks either originating from one country and intercepted by the other, or affecting the management or the biology of the stocks of the other country. The objective of the original treaty and subsequently negotiated agreements (annexes) is to constrain harvest on both sides of the United States-Canada border and to rebuild depressed salmon stocks. The Pacific Salmon Commission was formed to oversee implementation of the treaty and to negotiate periodic revisions of the annex fishing regimes. Although the emphasis of the work of the Pacific Salmon Commission under the Pacific Salmon Treaty was salmon, it also was charged with taking into account the conservation of steelhead while fulfilling its other functions.

In general, risks to natural-origin salmon and steelhead (e.g., competition and predation in fresh and marine water, genetics) from hatchery programs, and associated benefits for fisheries, increased as production levels increased (Subsection 2.0, General Effects (Risks and Benefits) of Hatchery Programs to Salmon and Steelhead, and Appendix B, Hatchery Effects and Evaluation Methods for Fish, in the PS Hatcheries DEIS [NMFS 2014a]).

5.3 Present Conditions

As described in Subsection 5.2, Past Actions, substantial changes have occurred to land uses and the environment in the cumulative effects analysis area over the past century. Primary habitat degradation factors currently affecting aquatic organisms in the area, including the Duwamish-Green River Basin, include stormwater runoff and related toxic pollutants, decreased water quality due to loss of stream shading and agricultural/industrial runoff, continued increases in impervious surfaces, decreasing water quantity due to increased water withdrawals, overwater structures that impact shoreline habitat, riverbank and shoreline modifications that impact fish habitat in fresh and marine waters, light pollution, and a decrease of large woody structures in streams (NWIFC 2016).

Federal, state, and local laws, regulations, and policies are in place in the cumulative effects analysis area to protect the environment from negative effects of development projects (NMFS 2011). Federal environmental protection agencies implement Federal laws, regulations, and policies that are designed to conserve the nation's air, water, and land resources. Regulatory processes involve agency review, approval, and permitting of development actions. Regulatory examples include the ESA, Magnuson-Stevens Fishery Conservation and Management Act, and Clean Water Act. In addition to Federal laws and processes, state and local laws, regulations, and guidelines help address the effects of commercial, industrial, and residential development on natural ecosystems. In Washington State, various HCPs are being implemented, such as the City of Tacoma's HCP for water supply operations in the Green River (Tacoma Water 2001) and the Washington Department of Natural Resources (DNR) Forest Practices HCP (DNR 2005). In the areas affected, HCPs provide federally-approved long-term, landscape-based protection of federally listed and non-listed species considered at risk of extinction. Other state laws, regulations, and guidance include the Washington State Environmental Policy Act and its Endangered, Threatened, and Sensitive Species Act as described in Subsection 1.7.10, Washington State Endangered, Threatened, and Sensitive Species Act. A law unique to the State of Washington is the Growth Management Act (Chapter 36.70A RCW), which requires local land use planning and development of regulations, including identification and protection of critical areas from future development. King County recently completed an update of its comprehensive plan in 2016 (King County 2016a) to continue to protect critical areas under the state's Growth Management Act.

Other Federal laws and regulatory processes pertaining to development include the Federal Coastal Zone Management Act, Federal Energy Regulatory Commission permit approvals and renewals, and USACE project approvals. Other Washington State laws and regulatory processes pertaining to development include the Shoreline Management Act (90.58 RCW), Hydraulic Project Approval, Water Pollution Control Act, Water Code (90.03 RCW), Minimum Water Flows and Levels Act of 1967 (RCW 90.22), the Water Resources Act of 1971 (90.54 RCW), and Watershed Planning Act (90.82 080 RCW).

The intent of these policies and processes is to help ensure that development projects occur in a manner that protects sensitive natural resources. The environmental goals and objectives of these policies and processes are aimed at protecting ecosystems from activities that are regulated; however, not all activities are regulated to the same extent (e.g., large developments tend to be regulated more than smaller developments). All environmental goals and objectives are unlikely to be met (NMFS 2011; NWIFC 2016), and Zier and Gaydos (2016) suggest that negative ecosystem impacts are outpacing recovery efforts that include existing protective regulations and policies. Unregulated or minimally regulated activities may have led to cumulative effects on sensitive natural resources. In addition, habitat restoration strategies are being implemented to protect and restore remaining habitat (NMFS 2014b; PSP (2015) and to evaluate new proposals to avoid continued habitat degradation (King County 2016b).

Despite the changes in environmental condition that have occurred, the Puget Sound area remains ecologically diverse, containing a wide range of species and habitats (EPA 2011). Similar to other river basins in the Puget Sound area, the topography of the area ranges from marine ecosystems at sea level to the crest of the Cascade Mountains, which creates highly variable local-scale climates and, in combination with diverse soil types, results in a wide variety of environmental conditions. This variety is important because the river basin has the capability to support a diversity of fish species and life histories as described in Subsection 3.2, Salmon and Steelhead, and Subsection 3.3, Other Fish Species. For example, the diversity (genetic and behavioral) represented by the variation in Chinook salmon and steelhead life histories helps both species adapt to short- and long-term changes in their environment over time (McElhany et al. 2000).

The Center for Biological Diversity (2005) identified 7,000 species of organisms that occur in the Puget Sound area, which is considered one of the most productive areas for salmon along the Pacific Coast (Lombard 2006). However, the World Wildlife Fund (2012) considers the remaining natural habitats in the Puget Sound area to be threatened from ongoing urbanization, agricultural practices, fire suppression, introduction of noxious weeds, flood control efforts, operation of hydroelectric dams, and logging. For example, these human-induced factors (e.g., habitat modifications, water quality degradation, presence of dams and fish barriers, and other factors) have affected overall abundance, productivity, diversity, and distribution of salmon and steelhead. Habitat degradation due to human-dominated uses continues to occur in freshwater and estuarine habitats of Puget Sound (PSP 2015). For example, forest lands continue to be converted for development, and freshwater and estuarine areas continue to be degraded and lost faster than habitat can be restored (NMFS 2011; NWIFC 2012). In addition, aquaculture (farming of fish, shellfish, and aquatic plants in fresh and marine water for direct harvest), which is practiced in Washington, has grown over time and has the potential to affect other aquatic organisms.

As described in Subsection 3.2.2.1, General Effects of Puget Sound Salmon and Steelhead Hatchery Programs, the co-managers' 90 hatchery programs release about 167 million juvenile hatchery-origin salmon and steelhead into Puget Sound freshwater and marine areas each year, including 50.0 million Chinook salmon, 15.3 million coho salmon, 54.1 million chum salmon, 4.1 million pink salmon, 42.3 million sockeye salmon, and 1.2 million steelhead (Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities).

Salmon and steelhead hatchery facilities and practices have become more sophisticated and efficient over time as new technologies and policies are applied to reduce impacts to natural-origin salmon and steelhead. For example, although the general risks to natural-origin salmon and steelhead from hatchery programs (e.g., competition and predation in fresh water and marine water, genetics) and associated benefits (e.g., fisheries) are ongoing, risks are being reduced through development of contemporary policies and associated techniques that hatchery operators are implementing for hatchery improvements

(HSRG 2014). For example, to reduce or limit the risks of gene flow from hatchery stocks to native fish, hatchery operators are developing more appropriate hatchery broodstocks (e.g., use of out-of-DPS hatchery-origin Chambers Creek early winter-run steelhead has been phased out in Lower Columbia River tributaries, and a local broodstock is being developed [NMFS 2017]), limiting the extent to which hatchery-origin fish can be transferred from one basin to another, marking hatchery-origin fish for harvest management and stock assessment purposes (and to improve abilities to distinguish hatchery-origin from natural-origin fish), actively managing unintended natural spawning and straying by hatchery-origin fish, and reducing production levels in some cases (NMFS 2017).

Hatchery managers are also making improvements in fish disease management and improving their understanding of and approaches to reducing ecological impacts (Kostow 2012). Hatcheries are now also used in some circumstances for conservation and recovery purposes by using locally adapted native broodstocks (e.g., South Fork Nooksack Chinook salmon hatchery program [Lummi Indian Nation 2015]), while potentially providing for some harvest benefits (Subsection 3.2, Fish, in the PS Hatcheries DEIS (NMFS 2014a). Notwithstanding these beneficial changes, hatcheries continue to affect salmon and steelhead in Puget Sound through genetic introgression, competition, predation, and disease (see also Subsection 5.4.4, Hatchery Production).

Commercial, recreational, and tribal harvests of salmon and steelhead continue under the legal framework of *United States v. Washington* (1974) (described in Subsection 5.2, Past Actions), which is the primary driver for defining fish production and harvest objectives in Puget Sound. The Puget Sound Comprehensive Chinook Management Plan (Puget Sound Treaty Tribes and WDFW 2004) expired in 2014. Since then, WDFW and Puget Sound tribes have developed yearly plans. In addition, the current Pacific Salmon Treaty agreement (or annex) governs Chinook salmon and several other salmon and steelhead species from 2009 through 2018. Harvest is also regulated under the Pacific Salmon Treaty for an equitable harvest sharing between the United States and Canada (described in Subsection 5.2, Past Actions).

Altogether, the conditions described in this subsection (e.g., development and habitat degradation, hatchery practices, and fisheries) are expected to continue under future actions and conditions as described below.

5.4 Future Actions and Conditions

Reasonably foreseeable future actions include climate change, development, planned habitat restoration activities, hatchery production, and fisheries. Many plans, regulations, and laws are in place to reduce effects of human development and to restore habitat function. As discussed in Subsection 5.3, Present Conditions, recent reviews suggest that negative ecosystem impacts may outpace recovery efforts that include existing regulations and policies. Thus, if trends of the past and present continue, it is unclear if these plans, regulations, and laws will be successful in meeting their environmental goals and objectives. In addition, it is not possible to predict the magnitude of effects from future development and habitat restoration with certainty. When combined with climate change, cumulative effects are broadly analyzed for each resource as described in Subsection 5.5, Cumulative Effects by Resource.

This cumulative effects analysis qualitatively assesses the overall trends in cumulative effects considering past, present, and reasonably foreseeable future actions, and describes how the alternatives would contribute to those trends.

5.4.1 Climate Change

The changing climate is recognized as a long-term trend that is occurring throughout the world. Within the Pacific Northwest, Ford (2011) summarized expected climate changes in the coming years as leading to the physical and chemical changes listed below (certainty of occurring is in parentheses):

- Increased air temperature, particularly during the summer months (high certainty)
- Increased winter precipitation (low certainty)
- Decreased summer precipitation (low certainty)
- Reduced winter and spring snowpack (high certainty)
- Reduced summer stream flow (high certainty)
- Earlier spring peak flow (high certainty)
- Increased intense, heavy rain conditions (moderate certainty)
- Increased flood frequency and intensity (moderate certainty)
- Higher summer stream temperatures (moderate certainty)
- Higher sea level (high certainty)
- Higher ocean temperatures (high certainty)
- Intensified upwelling in the ocean (moderate certainty)
- Delayed transition of ocean upwelling in the spring (moderate certainty)
- Increased ocean acidity (high certainty)

These changes will affect the human environment and biological ecosystems within the cumulative effects analysis area (Ecology 2012a; Mauger et al. 2015; NWFSC 2015; King County 2016a). Changes to organisms and their habitats are likely to include shifts in timing of life history events, changes in growth and development rates, and changes in habitat and ecosystem structure, including a rise in sea level and increased flooding (Littell et al. 2009; Johannessen and Macdonald 2009).

For the Pacific Northwest portion of the United States, Hamlet (2011) notes that climate change will have multiple effects. Expected effects include:

- Overtaxing of stormwater management systems at certain times
- Increases in sediment inputs into water bodies from roads
- Increases in landslides
- Increases in debris flows and related scouring that damage human infrastructure
- Increases in fires and related loss of life and property
- Reductions in the quantity of water available to meet multiple needs at certain times of year (e.g., irrigated agriculture, human consumption, and habitat for fish)
- Shifts in irrigation and growing seasons
- Changes in plant, fish, and wildlife species' distributions and increases in potential for invasive species
- Declines in hydropower production
- Changes in heating and energy demand
- Impacts to homes along coastal shorelines from beach erosion and rising sea levels

The most heavily affected ecosystems and human activities along the Pacific coast are likely to be near areas having high human population densities and along the continental shelves off Oregon and Washington (Halpern et al. 2009).

Note that predictions of climate change and effects described above are based on expected changes in greenhouse gas emissions over time and climate change in response to these emissions. Since it is impossible to predict the exact amount of greenhouse gas emissions resulting from future human activities, models are used to estimate effects of climate change under a wide range of change scenarios (from low to high changes) (Mauger et al. 2015).

Operation of the 10 existing and new hatchery programs in the Duwamish-Green River Basin would not be expected to substantially affect climate change under any alternative because broodstock collection, spawning, rearing, and release activities that are the primary actions at the hatcheries would be negligible sources of greenhouse gas emissions. However, under all of the alternatives except Alternative 3 (Termination), adult salmon and steelhead trapped at the Tacoma Water Diversion for use as broodstock each year would be transported by truck weekly for up to 3 months to hatchery facilities (e.g., Soos Creek Hatchery, FRF). Trucks would also be used for 1 day each year to transfer salmon and steelhead from hatchery facilities to rearing facilities (e.g., from Soos Creek Hatchery to Icy Creek and Palmer rearing ponds) and from hatchery facilities to release areas (e.g., Elliott Bay net pens and potentially from the FRF to stream locations above Howard Hanson Dam). The fish transport trucks used for these activities would comply with Washington State emission control standards required for vehicle licensing to minimize air pollution. Emissions from these localized and infrequent activities would not be expected to contribute in any meaningful way to greenhouse gases adversely affecting the environment.

5.4.2 Development

Future human population growth in the Puget Sound area is expected to continue over the next 15 years. For example, the number of people in the Puget Sound area is expected to grow by over 40,000 residents per year (PSRC 2013), and the number of people in King County alone (location of the project area) is expected to grow from 2,029,053 residents in 2015 to 2,262,977 residents by 2030, an increase of approximately 11 percent (Washington State Office of Financial Management 2016). This growth will result in increased demand for housing, transportation, food, water, energy, and commerce. These needs will result in changes to existing land uses because of increases in residential and commercial development and roads, increases in impervious surfaces, conversions of private agricultural and forested lands to developed uses, increases in use of non-native species and increased potential for invasive species, and redevelopment and infill of existing developed lands. The need to provide food and supplies to a growing human population in the cumulative effects analysis area will result in increases in shipping, withdrawals of fresh water to meet increasing food and resource requirements, and energy demands. Although the rate of urban sprawl has been decreasing in comparison to previous increases in the late 20th century (PSRC 2012), development will continue to affect the natural resources in the cumulative effects analysis area.

To help protect environmental resources in the cumulative effects analysis area from potential future development effects, Federal environmental protection agencies will continue to implement Federal laws, regulations, and policies that are designed to conserve the nation's air, water, and land resources. Regulatory processes will involve agency review, approval, and permitting of development actions. Regulatory examples include the ESA, Magnuson-Stevens Fishery Conservation and Management Act, and Clean Water Act. In Washington, aquaculture facilities (such as enclosed facilities for raising and selling fish, shellfish [including geoducks], and aquatic plants) are regulated by Washington State. These environmental laws will continue to require agency review and approval of proposed activities.

In addition to Federal laws and processes, state and local laws, regulations, and guidelines will help decrease the effects of future commercial, industrial, and residential development on natural ecosystems. In Washington State, various HCPs will continue to be implemented, such as the City of Tacoma's HCP for water supply operations in the Green River (Tacoma Water 2001), DNR Forest Practices HCP (DNR 2005), and other HCPs that are in development (e.g., WDFW Wildlife Areas HCP). In the areas affected, the HCPs provide federally-approved long-term, landscape-based protection of federally listed and non-listed species considered at risk of extinction. Other state laws, regulations, and guidance include the Washington State Environmental Policy Act, and its Endangered, Threatened, and Sensitive Species Act as described in Subsection 1.7.10, Washington State Endangered, Threatened, and Sensitive Species Act.

A law unique to the State of Washington is the Growth Management Act (Chapter 36.70A RCW), which requires local land use planning and development of regulations, including identification and protection of critical areas from future development. King County recently completed an update of its comprehensive plan in 2016 (King County 2016a) to continue to protect critical areas under the state's Growth Management Act. These Federal, state, and local regulations will help to decrease habitat fragmentation and residential development and urban sprawl in sensitive habitat and ecosystems, and decrease contamination of air, lands, and waterways.

In Washington, state and local land use laws, regulations, and policies will also help protect the natural environment from future development effects. For example, the PSRC developed Vision 2040 to identify goals that support preservation and restoration of the natural environment along with development through multicounty policies that address environmental stewardship (PSRC 2009). Vision 2040 is a growth management, environmental, economic, and transportation strategy for central Puget Sound that also includes objectives focusing on sustainable development, as well as planning for a comprehensive green space strategy. Other local policies and initiatives by counties and municipalities include designation of areas best suited for future development and areas that should be protected, such as local sensitive areas ordinances and shoreline protection acts.

In summary, Federal, state, and local laws, regulations, and policies will be applied in the cumulative effects analysis area with the intent to implement and better enforce environmental protections for proposed future development projects. These laws, regulations, and policies include processes for public input, agency reviews, mitigation measures, permitting, and monitoring. The intent of these processes is to help ensure that development projects will occur in a manner that protects sensitive natural resources. The environmental goals and objectives of these processes are aimed at protecting ecosystems from activities that are regulated; however, not all activities are regulated to the same extent (e.g., large developments tend to be regulated more than smaller developments).

Further, if trends of the past and present continue in the future, it is unlikely that all environmental goals and objectives will be successfully met by such processes. For example, in an analysis of the implementation of the Puget Sound Chinook salmon recovery plan, NMFS (2011) found that anticipated updates to some protective regulations are occurring more slowly than anticipated and that there may be inconsistencies among regulatory policies and actions that would benefit recovery. In addition, NWIFC (2016) and Zier and Gaydos (2016) note that ecosystem impacts are likely to outpace recovery efforts. Unregulated or minimally regulated activities may lead to cumulative effects on sensitive natural resources over time. Thus, although Federal, state, and local laws, regulations, policies, and guidelines are in place to protect environmental resources from future development effects, there will continue to be some cumulative environmental degradation in the future from development, albeit likely to a lesser extent than has occurred historically when environmental regulatory protections did not exist or were not comprehensive and collaborative.

5.4.3 Habitat Restoration

To help counterbalance the human-induced changes that will affect biodiversity in the cumulative effects analysis area (Subsection 5.4.2, Development), future funding for environmental restoration efforts will continue to help foster a healthy environment and sustainable ecosystem (PSRC 2009). Federal agencies and organizations are expected to continue to support habitat protection and restoration initiatives and processes in the Puget Sound area, including projects such as the Puget Sound Nearshore Ecosystem Restoration Project (Puget Sound Nearshore Ecosystem Restoration Partnership 2013) for the purpose of identifying ecosystem degradation, formulating solutions, and recommending actions and projects to help restore Puget Sound.

The Puget Sound Partnership is a collaborative initiative that will continue efforts to recover the Puget Sound ecosystem (including listed salmon, steelhead, and other species) with the support of NMFS, USFWS, Washington State, Puget Sound tribes, local governments, and key non-governmental organizations. In addition, implementation of salmon recovery plans in Puget Sound (72 Fed. Reg. 2493, January 19, 2007, for Chinook salmon, and 72 Fed. Reg. 29121, May 24, 2007, for Hood Canal summer-run chum salmon) will continue to recover salmon and steelhead and the habitats on which they depend in Puget Sound (Subsection 1.7.12, Recovery Plans for Puget Sound Salmon and Steelhead). It is expected that NMFS will continue to provide funding for habitat restoration initiatives through the Pacific Coastal Salmon Recovery Fund (NMFS 2015). However, habitat will likely continue to decline faster than it is being restored, and habitat protection tools will continue to need improvement to protect the long-term sustainability of resources in the cumulative effects analysis area (NMFS 2011; NWIFC 2016).

It is expected that Washington State will continue to support habitat restoration in the cumulative effects analysis area through actions similar to recent support efforts. In addition to cooperative partnerships with Federal agencies as described above, Ecology (2012b) reserves funding for cleanups of toxics in Puget Sound. Although receiving substantial Federal support, the Puget Sound Partnership is a state agency that was created to lead the recovery of the Puget Sound ecosystem (PSP 2010). The agency created, and is overseeing implementation of, a roadmap to healthy Puget Sound watersheds and marine areas. Objectives include prioritizing cleanup and improvement projects; coordinating Federal, state, local, tribal, and private resources; and ensuring that all agencies and funding partners are working cooperatively. Washington State also created the Salmon Recovery Funding Board, which administers Federal and Washington State funds to protect and restore salmon and steelhead habitat.

Priorities for recovering the Puget Sound ecosystem include reducing land development pressure on ecologically important and sensitive areas, protecting and restoring floodplain function, and protecting and recovering salmon and freshwater resources (PSP 2015). In marine and freshwater areas, development will continue to be encouraged away from ecologically important and sensitive nearshore areas and estuaries, and efforts will be made to reduce sources of pollution into Puget Sound (including stormwater runoff). Approaches will be used to help preserve and restore the natural functions of the ecosystem and support sustainable economic growth.

Habitat restoration efforts by various organizations will continue work to restore degraded habitat conditions in the Duwamish-Green River Basin. For example, improvements in air, land, and water conditions in the basin will occur via implementation of a partnership strategy to coordinate work and funding among public and private organizations (King County 2014). Other examples include implementation of a plan to identify and clean up hazardous substances in the Duwamish River (NOAA (2013), implementation of a strategy to clean up contamination in the Lower Duwamish River

(EPA 2014), and continued implementation of the Green/Duwamish chapter of the recovery plan for Puget Sound salmon (Green/Duwamish and Central Puget Sound Watershed Water Resource Inventory Area 9 (WRIA 9) Steering Committee 2005, and amendments in 2007). Finally, a local non-profit organization will help to set priorities for restoration in the river basin (Our Green/Duwamish 2016). Similar smaller and more local community habitat restoration and protection efforts will continue to help protect and restore sensitive areas in the Puget Sound area.

In summary, degraded habitat from past and ongoing actions has contributed to Federal and state listings of fish and wildlife species (Subsection 3.2, Salmon and Steelhead; Subsection 3.3, Other Fish Species; and Subsection 3.4, Wildlife – Southern Resident Killer Whale). A variety of Federal, state, and local programs are expected to help restore degraded habitat conditions in the cumulative effects analysis area. Collectively, these programs are expected to improve existing conditions resulting from habitat degradation and long-term detrimental cumulative impacts to natural resources in the cumulative effects analysis area. However, these programs are not expected to eliminate negative impacts to the resources.

5.4.4 Hatchery Production

Similar to changes in hatchery programs, as described in Subsection 5.3, Present Conditions, it is likely that the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the cumulative effects analysis area will change over time in response to new information and evolving management objectives. These changes are likely to reduce effects on natural-origin salmon and steelhead such as genetic effects and competition and predation risks that are described in Subsection 3.2.2.1, General Effects of Puget Sound Salmon and Steelhead Hatchery Programs, especially for those species that are listed under the ESA. For example, effects on natural-origin salmon and steelhead are expected to decrease over time to the extent that hatchery programs are reviewed and approved by NMFS under the ESA. Hatchery program compliance with conservation provisions of the ESA will ensure that listed species are not jeopardized and that "take" under the ESA from salmon and steelhead hatchery programs is minimized or avoided.

Where needed, reductions in effects on listed salmon and steelhead may occur through changes such as refinement of times and locations of fish releases to reduce risks of competition and predation; management of overlap in hatchery-origin and natural-origin spawners to meet gene flow objectives; decreased use of isolated hatchery programs; increased use of integrated hatchery programs for conservation purposes; incorporation of new research results and improved BMPs for hatchery operations; decreased production levels; or termination of programs. Similar changes are expected for non-listed species in many cases as well, motivated by the desire to reduce negative effects where possible and to help avoid species from becoming listed.

5.4.5 Fisheries

It is likely that the salmon and steelhead fisheries in the analysis area (tribal and non-tribal commercial fisheries) and non-tribal recreational fisheries described in Subsection 3.2.3.5, Incidental Fishing, will change over time in response to new information and revised management objectives. Such fisheries include those in the Duwamish-Green River Basin and adjacent marine catch areas (e.g., Catch Areas 10 and 10A) for fall-run Chinook salmon, summer-run steelhead, coho salmon, and chum salmon that target hatchery-origin fish produced by the hatchery programs in the basin. These changes are likely to reduce effects on natural-origin salmon and steelhead listed under the ESA. For example, effects on natural-origin salmon and steelhead are expected to decrease over time to the extent that fisheries management programs continue to be reviewed and approved by NMFS to protect listed Chinook salmon and steelhead under the ESA, as evidenced by the beneficial changes to programs that have thus far undergone ESA review (e.g., NMFS 2016). Fisheries management program compliance with conservation provisions of the ESA will ensure that listed species are not jeopardized and that "take" under the ESA from salmon and steelhead fisheries is minimized or avoided. Where needed, reductions in effects on listed salmon and steelhead may occur through changes in areas or timing of fisheries, or changes in types of harvest methods used. To the extent that improvements in the status of listed salmon and steelhead occurs, potential future fisheries may be considered.

5.5 Cumulative Effects by Resource

Provided below is an analysis of the cumulative effects of climate change, development, habitat restoration, hatchery production, and fisheries under the alternatives and for each resource analyzed in this EIS. Future actions in the overall cumulative effects analysis area are described in Subsection 5.4, Future Actions and Conditions. This subsection considers effects that may occur as a result of the alternatives being implemented at the same time as other anticipated future actions, and discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions for water quantity and quality, salmon and steelhead, other fish species, wildlife – Southern Resident killer whale, socioeconomics, environmental justice, and human health resources.

5.5.1 Water Quantity and Quality

Subsection 3.1, Water Quantity and Quality, describes the baseline conditions of water quantity and quality within the analysis area. Water quality information for that analysis area is also described in

Subsection 3.6.2, Water Quantity, in the PS Hatcheries DEIS (NMFS 2014a). These conditions are the result of many years of climate change, development, habitat restoration, and operation of hatchery programs. The effects of the alternatives on water quantity and quality are described in Subsection 4.1, Water Quantity and Quality.

Successful operation of hatcheries depends on a constant supply of high-quality surface, spring, or groundwater that, after use in hatchery facilities, is discharged to adjacent receiving environments. Climate change and development are expected to affect water quality by increasing water temperatures and affect water quantity by changing seasonality and magnitude of river flows and groundwater. Although existing regulations are intended to help protect water quality and quantity from effects related to future development, if past and present trends continue into the future, the effectiveness of these regulations over time is likely to vary. Future habitat restoration would likely improve water quality and quantity (such as helping to decrease water temperatures through shading, decrease sedimentation, decrease water diversions, and protect aquifers and recharge areas).

As discussed in Subsection 5.4.4, Hatchery Production, changes in hatchery programs may occur over time. These changes are unlikely to change water quantity or improve water quality because water use would be similar regardless of program type. However, reductions in hatchery production or terminations of programs could improve water quantity and quality to the extent that less water is used in hatchery operations and discharged into receiving waters, although hatchery operators may continue to exercise their existing water rights. Fisheries on salmon and steelhead would not be expected to affect water quantity or substantially affect water quality. Operations of motorized boats used for fishing may lead to some unintentional releases of motor oil and gasoline into the aquatic environment. Overall, cumulative effects of climate change, development, and hatchery production on water quantity and quality may reduce available water resources from what is described in Subsection 4.1, Water Quantity. These negative effects may be offset to some extent by habitat restoration and potential decreases in hatchery production; however, these actions may not fully, or even partially, mitigate for the greater impacts of climate change and development on water quantity and quality, although this is the goal of many of the restoration programs.

Water quantity, water rights, and water availability in the Green River were assessed by Northwest Hydraulics Consultants (2005). Flows in the Green River are affected by diversion of water by the City of Tacoma for residential and industrial uses, management of a summer conservation pool at Howard Hanson Dam to provide adequate surface water flows for salmon and steelhead below the dam, and Tacoma Water’s agreement to provide minimum continuous instream flows in the Green River.

Assessment of flow sufficiency at Howard Hanson Dam is regularly monitored by USACE in consultation with the Muckleshoot Indian Tribe, WDFW, Tacoma Water, and other public and private organizations. The Duwamish River portion of the Duwamish-Green River Basin does not have large water diversions as described for the Green River watershed.

In summary, under all alternatives, it is likely that cumulative effects from climate change, development, habitat restoration, and hatchery production would impact water quantity (increased demand on limited water supplies) and water quality (particularly water temperature changes) in the cumulative effects analysis area relative to conditions considered in Subsection 4.1, Water Quantity, and as described in Subsection 4.6.3, Water Quality, in the PS Hatcheries DEIS (NMFS 2014a). None of the alternatives (including scenarios for FRF hatchery programs that are associated with potential fish passage at Howard Hanson Dam) would affect the overall trend in cumulative effects on water quantity and quality.

5.5.2 Salmon and Steelhead

Subsection 3.2, Salmon and Steelhead, describes baseline conditions for salmon and steelhead. These conditions are the result of many years of climate change, development, habitat restoration, hatchery production, and fisheries. The expected direct and indirect effects of the alternatives on salmon and steelhead are described in Subsection 4.2, Salmon and Steelhead.

Salmon and steelhead abundance naturally alternates between high and low levels on large temporal and spatial patterns that may last centuries and on more complex ecological scales than can be easily observed (Rogers et al. 2013). Current run sizes of salmon and steelhead in the cumulative effects analysis area are about 8 percent of historical run sizes in Puget Sound (Lackey et al. 2006). Thus, cumulative effects on salmon and steelhead may be greater than the direct and indirect effects of each alternative as analyzed in Subsection 4.2, Salmon and Steelhead, under all alternatives.

The effects of climate change on salmon and steelhead are described in general in ISAB (2007) and would vary among species and among species' life history stages (NWFSC 2015). Effects of climate change may affect virtually every species and life history type of salmon and steelhead in the cumulative effects analysis area (Glick et al. 2007; Mantua et al. 2009; Mauger et al. 2015). Cumulative effects from climate change, particularly changes in stream flow and water temperatures, would likely affect hatchery-origin and natural-origin salmon and steelhead life stages in various ways, as described below and shown in Table 48.

Table 48. Examples of potential impacts of climate change by salmon and steelhead life stage under all alternatives.

Life Stage	Effects
Egg	1) Increased water temperatures and decreased flows during spawning migrations for some species would increase pre-spawning mortality and reduce egg deposition. 2) Increased maintenance metabolism would lead to smaller fry. 3) Lower disease resistance may lead to lower survival. 4) Changed thermal regime during incubation may lead to lower survival. 5) Faster embryonic development would lead to earlier hatching. 6) Increased mortality would occur for some species because of more frequent winter flood flows as snow level rises. 7) Lower flows would decrease access to or availability of spawning areas.
Spring and Summer Rearing	1) Faster yolk utilization may lead to early emergence. 2) Smaller fry are expected to have lower survival rates. 3) Higher maintenance metabolism would lead to greater food demand. 4) Growth rates would be slower if food is limited or if temperature increases exceed optimal levels; growth could be enhanced where food is available and temperatures do not reach stressful levels. 5) Predation risk would increase if temperatures exceed optimal levels. 6) Lower flows would decrease rearing habitat capacity. 7) Sea level rise would eliminate or diminish the rearing capacity of tidal wetland habitats for rearing salmon and would reduce the area of estuarine beaches for spawning by forage fishes.
Overwinter Rearing	1) Smaller size at start of winter is expected to result in lower winter survival. 2) Mortality would increase because of more frequent flood flows as snow level rises. 3) Warmer winter temperatures would lead to higher metabolic demands, which may also contribute to lower winter survival if food is limited, or higher winter survival if growth and size are enhanced. 4) Warmer winters may increase predator activity/hunger, which can also contribute to lower winter survival.

Sources: ISAB 2007; Glick et al. 2007; Beamish et al. 2009; Beechie et al. 2013; Wade et al. 2013; Mauger et al. 2015

For Puget Sound steelhead, changes in stream flows may be particularly important (Wade et al. 2013). For example, as winter flows become larger and more frequent, summer flows would decrease. This would likely increase pre-spawning mortality of adults and result in less space for juveniles rearing in streams. In a vulnerability analysis that modeled the impacts from climate changes on a wide variety of resources in the Stillaguamish River and watersheds in northern Puget Sound, Krosby et al. (2016) concluded that Chinook salmon, coho salmon, bull trout, and steelhead would be moderately vulnerable to the effects of climate change by the 2050s and extremely vulnerable to such effects by the 2080s because of the species' narrow thermal tolerances and sensitivity to disturbances. Under all alternatives, impacts to salmon and steelhead from climate change are expected to be similar, because climate change would impact fish habitat under each alternative in the same manner. In other words, when added to the effects of climate change on habitat conditions (e.g., changes in stream flow and water temperature), the effects on resources (e.g., fish) under the alternatives on salmon and steelhead would not be substantially different.

As summarized in a recent review (ISAB 2015), density-dependent effects on natural-origin fish from releases of hatchery-origin fish in fresh water and ocean conditions may occur as environmental conditions change as a result of climate change. Such effects may be especially relevant where releases of hatchery-origin fish are especially large (e.g., chum salmon, pink salmon, and sockeye salmon).

Previous and new developments (such as residential, commercial, transportation, and energy development); accidental discharges of oil, gas, and other hazardous materials; and the potential for landowner and developer noncompliance with regulations continue to affect aquatic habitat used by salmon and steelhead (Puget Sound Action Team 2007). Although regulatory changes for increased environmental protection (such as local critical areas ordinances), monitoring, and enforcement have helped reduce impacts of development on salmon and steelhead in fresh and marine waters, development may continue to reduce salmon and steelhead habitat, decrease water quantity and quality, and contribute to salmon and steelhead mortality. These developments result in environmental effects such as land conversion, sedimentation, impervious surface water runoff to streams, changes in stream flow because of increased consumptive uses, shoreline armoring effects, channelization in lower river areas, barriers to fish passage, and other types of environmental changes that would continue to affect hatchery-origin and natural-origin salmon and steelhead (Quinn 2010).

The primary cause of these development changes is the continued increase in human population in the cumulative effects analysis area (Subsection 5.4.2, Development), which also leads to fisheries management challenges associated with overfishing (Puget Sound Action Team 2007). Development would more likely affect species that reside in lower river areas (such as floodplains and estuaries) most directly because that is where development tends to be concentrated. Effects from development are expected to affect salmon and steelhead similarly under all alternatives because preferred development sites would not change by alternative scenario.

Restoration of habitat in the cumulative effects analysis area, where it occurs, will improve salmon and steelhead habitat in general under all alternatives, with particular benefits to freshwater and estuarine environments considered to be important for the survival and reproduction of fish. As a result, habitat restoration would be expected to improve fish survival in local areas (Puget Sound Action Team 2007) to some extent. However, habitat restoration alone will not substantially increase survival and abundance of salmon and steelhead. In addition, the extent of habitat restoration is dependent on continued funding, which is difficult to predict when economic recessions occur or governments experience deficits. Thus, to this indeterminate level, benefits from habitat restoration are expected to affect salmon and steelhead survival similarly under all alternatives. Examples of such benefits may include increased habitat quality for foraging and spawning, improved water quality for fish survival, and increased fish passage through culverts to previously blocked habitat.

The potential benefits of habitat restoration actions within the cumulative effects analysis area are difficult to quantify, but are expected to occur in localized areas where the activities occur. These actions may not fully mitigate for the impacts of climate change and development on fish and wildlife and their associated habitats. However, climate change and development will continue to occur over time and affect aquatic habitat, while habitat restoration (which is dependent on funding and is localized in areas where agencies and stakeholders' habitat restoration actions occur) is less certain under all alternatives.

The effects on natural-origin salmon and steelhead from future releases from salmon and steelhead hatcheries are expected to decrease over time, especially for listed species, as hatchery programs are reviewed and approved under the ESA (Subsection 5.4.4, Hatchery Production). For example, reduction of genetic risks (Subsection 3.2.3.1, Genetics; Subsection 2.1.3, Genetics, in Appendix B of the PS Hatcheries DEIS [NMFS 2014a]) may occur through changes such as application of new research results that lead to improved BMPs, increased use of integrated hatchery programs, and reductions in production levels. Over time, changes like these would also be expected to reduce the ecological risks of competition and predation because BMPs would increase the efficiency of hatchery operations, and reduced production would reduce risks associated with releases of hatchery-origin fish in migration, rearing, and spawning areas. In general, continued hatchery releases within the cumulative effects analysis area, along with other observed environmental trends, as described in the following subsections, would affect continued long-term viability of natural-origin salmon and steelhead.

As described in Subsection 5.4.5, Fisheries, the fishery co-managers of the Puget Sound salmon and steelhead fisheries resource develop a cooperative management plan each year for salmon and steelhead fisheries in Puget Sound and its tributaries. These fisheries provide for tribal and non-tribal commercial fisheries, non-tribal recreational fisheries, and tribal ceremonial and subsistence uses.

WDFW and the Puget Sound treaty tribes jointly manage the salmon and steelhead harvest to avoid jeopardizing the survival or recovery of species listed under the ESA, including meeting the terms of applicable salmon and steelhead management plans and the Pacific Salmon Treaty. Management of Washington State's fisheries resources is expected to continue into the indefinite future and would change over time, based on pre-season forecasts of fisheries returns, such that harvest meets resource conservation needs, meets sustainable fisheries goals, and assures all parties are afforded their allotted harvest opportunity.

In summary, under all alternatives, it is likely that cumulative effects from climate change and development will continue to degrade aquatic habitat over time, and abundance and productivity of natural-origin salmon and steelhead populations may be reduced relative to conditions considered in Subsection 4.2, Salmon and Steelhead. Hatchery-origin salmon and steelhead may be similarly affected. Habitat restoration and associated (mostly localized) benefits to salmon and steelhead would be expected to continue, but not fully mitigate for all habitat degradation. In addition, effects on abundance and productivity of natural-origin salmon and steelhead from changes in hatchery production and fisheries would be expected to continue but may decrease over time. Although none of the alternatives (including scenarios for FRF hatchery programs that are associated with potential fish passage at Howard Hanson Dam) would affect the overall trend in cumulative effects on salmon and steelhead, Alternative 3 and Alternative 4 could help mitigate negative effects on salmon and steelhead, because under Alternative 3, hatchery programs would be terminated, and under Alternative 4, hatchery release levels would be reduced (unlike under Alternative 1 and Alternative 2).

5.5.3 Other Fish Species

Subsection 3.3, Other Fish Species, describes the baseline conditions of fish species other than salmon and steelhead. These conditions are the result of many years of climate change, development, habitat restoration, hatchery production, and fisheries. The effects of the alternatives on other fish species are described in Subsection 4.3, Other Fish Species.

Other fish species that have a relationship to salmon and steelhead include bull trout, rainbow trout, coastal cutthroat trout, sturgeon and lamprey, forage fish, groundfish, and resident freshwater fish (Subsection 3.3, Other Fish Species). Similar to salmon and steelhead species, these fish species require and use a diversity of habitats. However, similar to effects described above for salmon and steelhead, these other fish species (including bull trout) may also be affected by climate change and development because of the overall potential for loss or degradation of aquatic habitat or the inability to adapt to warmer water temperatures. In addition, climate change and development may attract non-native aquatic organisms (e.g., mussels, plants) that may, over time, out-compete native aquatic organisms that provide or affect habitat important to native fish (Patrick et al. 2012).

As discussed in Subsection 5.4.3, Habitat Restoration, the extent to which habitat restoration actions may mitigate impacts from climate change and development is difficult to predict. These actions may not fully mitigate for the effects of climate change and development.

As discussed in Subsection 5.4.4, Hatchery Production, changes in hatchery programs over time may affect other fish species that have a relationship to salmon and steelhead, including bull trout. For example, reductions in hatchery production or terminations of hatchery programs may decrease the prey base available for other fish species (like bull trout) that use salmon and steelhead as a food source.

Commercial and recreational fisheries are designed and operated to minimize the incidental catch of non-target species. Fisheries are continually reviewed and revised as needed to achieve conservation objectives and protect listed species. Thus over time, increases in impacts to other fish species from incidental harvest are not expected.

In summary, under all alternatives, it is likely that cumulative effects from climate change, development, habitat restoration, hatchery production, and fisheries on other fish species, including bull trout, would result in decreases to many other fish species over time in the cumulative effects analysis area. Cumulative effects on other fish species that compete with, prey on, or are prey items for salmon and steelhead may be greater than described under Subsection 4.3, Other Fish Species. None of the alternatives (including scenarios for FRF hatchery programs that are associated with potential fish passage at Howard Hanson Dam) would affect the overall trend in cumulative effects on other fish species, including bull trout, because the range of production levels under the alternatives (i.e., from 0 to 13,993,000 hatchery-origin salmon and steelhead juveniles in the Duwamish-Green River Basin) would be a small component of the total abundance of salmon and steelhead in the cumulative effects analysis area that these other fish species could compete with, prey on, or be prey items.

5.5.4 Wildlife – Southern Resident Killer Whale

Subsection 3.4, Wildlife – Southern Resident Killer Whale, describes the baseline conditions of wildlife (Southern Resident killer whale). These conditions represent the effects of many years of climate change, development, habitat restoration, hatchery production, and fisheries. The effects of the alternatives on wildlife in Puget Sound are described in Subsection 4.4, Wildlife – Southern Resident Killer Whale.

As described in Subsection 5.5.2, Salmon and Steelhead, climate change and development in the cumulative effects analysis area may reduce the abundance and productivity of natural-origin salmon and steelhead populations. Hatchery-origin salmon and steelhead may be similarly affected. Consequently, the total number of salmon and steelhead available as prey to wildlife may be lower than that considered in Subsection 4.4, Wildlife – Southern Resident Killer Whale. As described in Subsection 3.4, Wildlife – Southern Resident Killer Whale, effects would be greatest on wildlife species that have a relationship with salmon and steelhead, including Southern Resident killer whales. Other species with a relationship to salmon and steelhead include common merganser, bald eagle, and Caspian terns (PS Hatcheries DEIS [NMFS 2014a]). Cumulative effects on Southern Resident killer whales may include changes in their distribution in response to changes in the abundance and distribution of their food supply and decreases in abundance compared to that described in Subsection 4.4, Wildlife – Southern Resident Killer Whale. Effects on other wildlife species that have a relationship with salmon and steelhead may also occur depending on how their overall aquatic prey base (which includes salmon and steelhead) would also be affected by climate change, development, habitat restoration, and fisheries.

The potential benefits of habitat restoration actions within the cumulative effects analysis area are difficult to quantify. These actions may not fully, or even partially, mitigate for the effects of climate change and development on salmon and steelhead abundances.

As discussed in Subsection 5.4.4, Hatchery Production, and Subsection 5.4.5, Fisheries, changes in hatchery programs and fisheries, respectively, may occur over time. These changes may affect wildlife species that have a relationship to salmon and steelhead. For example, reductions in hatchery production or terminations of hatchery programs would decrease the prey base available for wildlife species that use salmon and steelhead as a food source (e.g., Southern Resident killer whales). Fisheries in Puget Sound may affect the extent that wildlife have access to prey or are preyed on by salmon and steelhead.

In summary, under all alternatives, it is likely that cumulative effects from climate change, development, habitat restoration, hatchery production, and fisheries would affect those wildlife species that have a relationship with salmon and steelhead (including Southern Resident killer whales) and may impact other wildlife based on whether their overall food supply would decrease or otherwise change in some way (e.g., distribution, composition) as a result of climate change, development, habitat restoration, hatchery production, and fisheries, relative to conditions considered in Subsection 4.4, Wildlife – Southern Resident Killer Whale. However, none of the alternatives (including scenarios for FRF hatchery programs that are associated with potential fish passage at Howard Hanson Dam) would affect the overall trend in cumulative effects on wildlife in general because the range of production levels under the alternatives (i.e., from 0 to 13,993,000 hatchery-origin salmon and steelhead juveniles from hatchery programs in the Duwamish-Green River Basin) would produce an unsubstantial component of the total number of prey items for, or predators of, wildlife in the cumulative effects analysis area. For example, the number of juvenile fall-run Chinook salmon from hatchery programs in the Duwamish-Green River under the alternatives ranges from 0 to 5,100,000, which would produce from 0 to 21,861 returning adults that would be available as food for Southern Resident killer whales (Subsection 4.4, Wildlife – Southern Resident Killer Whale). However, the estimated total annual abundance of adult Chinook salmon from Washington State and British Columbia waters that would be available as food for Southern Resident killer whales is considerably larger, averaging about 1,000,000 fish (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

5.5.5 Socioeconomics

Subsection 3.5, Socioeconomics, describes the baseline conditions for socioeconomics. These conditions represent the effects of many years of climate change, development, habitat restoration, hatchery production, and fisheries. The expected effects of the alternatives on socioeconomics are described in Subsection 4.5, Socioeconomics.

Although unquantifiable, climate change and development, as well as changes in hatchery production and fisheries, may reduce the number of salmon and steelhead available for harvest over time as described in Subsection 5.5.2, Salmon and Steelhead. This, in turn, may reduce expenditures and economic revenues from commercial and recreational fisheries relative to conditions considered in Subsection 4.5, Socioeconomics. Likewise, it may reduce the number of salmon and steelhead available to tribal members as a food source and may increase tribal reliance on other consumer goods or increase travel costs to participate in other fisheries.

The potential benefits of habitat restoration actions within the cumulative effects analysis area are difficult to quantify. These actions may not fully mitigate for the impacts of climate change and development on the abundance of fish that would be available for commercial or recreational harvest.

As discussed in Subsection 5.4.4, Hatchery Production, and Subsection 5.4.5, Fisheries, changes in fisheries that catch fish from hatcheries may occur over time. These changes may alter socioeconomic effects from hatchery production of salmon and steelhead from commercial and recreational fisheries, and hatchery operations. For example, reductions in hatchery production or terminations of hatchery programs may decrease the number of fish available for harvest and the associated ex-vessel values in commercial fisheries, decrease the associated number of trips and expenditures from recreational fishing, and decrease fishing and hatchery-related employment and income.

In summary, under all alternatives, it is likely that cumulative effects from climate change, development, habitat restoration, hatchery production, and fisheries would decrease the number of fish available for harvest and reduce expenditures and economic values relative to conditions considered in Subsection 4.5, Socioeconomics. None of the scenarios for FRF hatchery programs that are associated with potential fish passage at Howard Hanson Dam would affect the overall trend in cumulative effects on socioeconomics. The overall trend in cumulative effects associated with socioeconomics may be negatively affected under Alternative 3 and Alternative 4, because under Alternative 3, hatchery programs would be terminated, and under Alternative 4, hatchery release levels would be reduced 50 percent (unlike under Alternative 1 and Alternative 2). However, these changes would comprise a small component of the overall economic activity associated with salmon and steelhead production and harvest in the analysis area.

5.5.6 Environmental Justice

Subsection 3.6, Environmental Justice, describes environmental justice communities and user groups of concern in the analysis area. Environmental justice user groups and communities of concern within the cumulative effects analysis area include Indian tribes that fish for salmon and steelhead and low-income or minority communities. The expected effects of the alternatives on environmental justice are described in Subsection 4.6, Environmental Justice.

Climate change and development, as well as changes in hatchery production and fisheries, may reduce the number of salmon and steelhead available for commercial fisheries, and for tribal ceremonial and subsistence uses over time, as described in Subsection 5.5.2, Salmon and Steelhead, and Subsection 5.5.5, Socioeconomics. This, in turn, may reduce fishing opportunities in the analysis area relative to conditions considered in Subsection 4.6, Environmental Justice.

The potential benefits of habitat restoration actions within the cumulative effects analysis area are difficult to quantify. These actions may not fully mitigate for the impacts of climate change and development on the abundance of fish that would be available for commercial and recreational harvests and ceremonial and subsistence uses.

As discussed in Subsection 5.4.4, Hatchery Production, and Subsection 5.4.5, Fisheries, changes in hatchery programs and fisheries, respectively, may occur over time. Changes in hatchery programs may affect the number of salmon and steelhead available for harvest by environmental justice communities and user groups of concern.

In summary, under all alternatives, it is likely that cumulative effects from climate change, development, habitat restoration, hatchery production, and fisheries would decrease the number of fish available for harvest relative to conditions considered in Subsection 4.6, Environmental Justice. The overall trend in cumulative effects associated with environmental justice may be negatively affected under Alternative 3 and Alternative 4, because under Alternative 3, hatchery programs would be terminated, and under Alternative 4, hatchery release levels would be reduced 50 percent (unlike under Alternative 1 and Alternative 2). However, these changes would comprise a small percentage of the total number of harvestable salmon and steelhead in the cumulative effects analysis area available to environmental justice communities.

5.5.7 Human Health

Subsection 3.7, Human Health, describes the baseline conditions of human health within the analysis area. Human health information for that analysis area is also described in Subsection 3.7, Human Health, in the PS Hatcheries DEIS (NMFS 2014a). These conditions are the result of many years of climate change, development, habitat restoration, and operation of hatchery programs. The effects of the alternatives on human health are described in Subsection 4.7, Human Health.

As described in Subsection 3.7, Human Health, hatchery facilities use a variety of chemicals to maintain a clean environment for the production of disease-free hatchery-origin fish. Although consumption of fish generally provides nutritional values, hatchery-origin fish have the potential to accumulate hatchery chemicals prior to release. In addition, a number of diseases from parasites, viruses, and bacteria are potentially harmful to human health and may be transmitted from fish species to humans, primarily through seafood consumption (e.g., improperly or undercooked fish) or handling of infected fish or fish carcasses.

As discussed in Subsection 5.4.3, Habitat Restoration, the extent to which habitat restoration actions may mitigate impacts from climate change and development is difficult to predict. These actions may not fully mitigate for the effects of climate change and development.

As discussed in Subsection 5.4.4, Hatchery Production, changes in hatchery programs over time may affect human health resources. For example, reductions in hatchery production or terminations of hatchery programs may decrease the use of chemicals in hatchery operations.

In summary, under all alternatives, it is likely that cumulative effects from climate change, development, habitat restoration, and hatchery production would impact human health in the cumulative effects analysis area relative to conditions considered in Subsection 4.7, Human Health, and as described in Subsection 4.7, Human Health, in the PS Hatcheries DEIS (NMFS 2014a). None of the alternatives (including scenarios for FRF hatchery programs that are associated with potential fish passage at Howard Hanson Dam), would be expected to affect the overall trend in cumulative effects associated with the use of hatchery chemicals, the transfer of toxic contaminants from fish to humans, or the transmission of diseases from fish to humans. As a result, no cumulative effects would be expected beyond effects already discussed in Subsection 4.7, Human Health, for all alternatives.

5.6 Summary of Effects

Table 49 summarizes the combined effects of past actions (Subsection 5.2, Past Actions), present actions (Subsection 5.3, Present Actions), and reasonably foreseeable future actions (Subsection 5.4, Future Actions and Conditions), other than the Proposed Action and alternatives, affecting the environmental resources reviewed in this EIS. These effects include climate change, development, habitat restoration, hatchery production, and fisheries in the cumulative effects analysis area.

Table 49. Summary of effects of past, present, and reasonably foreseeable future actions on the affected resources evaluated in this EIS.

Affected Resource	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Past, Present, and Reasonably Foreseeable Future Actions
Water Quantity and Quality	Negligible to low negative due to water withdrawals and water quality degradation from development	Negligible to low negative	Low to moderate negative	Low negative
Salmon and Steelhead	Moderate to high negative due to development, habitat degradation, hatchery production, and fisheries	Mixed (negligible to moderate negative, to low positive) due to ESA compliance, habitat restoration, and hatchery practices, depending on species	Mixed (moderate negative to low positive), depending on species	Mixed (moderate negative to low positive), depending species
Other Fish Species	Mixed (negligible to low negative, to negligible positive) depending on species, due to development, habitat degradation, hatchery production, and fisheries	Mixed (negligible negative to negligible positive) depending on species	Negligible to low negative depending on species	Negligible to low negative depending on species
Wildlife – Southern Resident Killer Whale	Mixed (negligible to low negative, to low positive) due to development, habitat degradation, and hatchery production as a food source	Low positive due to ESA compliance	Negligible negative to low positive	Low positive
Socioeconomics	Moderate positive from benefits to recreational and tribal commercial fisheries, although some fisheries have been reduced in recent years as numbers of hatchery-origin fish available to harvest have declined	Low positive due to declines in harvest opportunities	Low positive	Low positive

Table 49. Summary of effects of past, present, and reasonably foreseeable future actions on the affected resources evaluated in this EIS, continued.

Affected Resource	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Past, Present, and Reasonably Foreseeable Future Actions
Environmental Justice	Low to moderate negative due to reductions in fish available for use by communities of concern and user groups of concern such as treaty Indian tribes	Low negative to low positive	Negligible negative	Low negative
Human Health	Negligible to low negative due to use of chemicals and therapeutics in hatchery operations	Negligible negative due to compliance with safety and label requirements	Negligible negative	Negligible negative

Table 50 summarizes the conclusions made above regarding effects of past, present, and reasonably foreseeable future actions affecting the environmental resources reviewed in this EIS (Table 49), when combined with the impacts under the alternatives (Subsection 5.5, Cumulative Effects by Resource). Definitions for effects terms in the tables are the same as described in Chapter 3, Affected Environment, and Chapter 4, Environmental Consequences. The relative magnitude and direction of effects are described using the following terms:

Undetectable: The impact would not be detectable.

Negligible: The impact would be at the lower levels of detection, and could be either positive or negative.

Low: The impact would be slight, but detectable, and could be either positive or negative.

Moderate: The impact would be readily apparent, and could be either positive or negative.

High: The impact would be greatly positive or severely negative.

Table 50. Summary of the cumulative effects under the alternatives.

Affected Resource	Baseline	Past, Present, and Reasonably Foreseeable Future Actions[1]	Effects of the Alternatives[2]	Effects of the Alternatives on Cumulative Effects
Water Quantity and Quality	Mixed (negligible to low negative)	Low negative	All alternatives would have low negative effects on water quantity, and Alternative 1, Alternative 2, and Alternative 4 would have negligible negative effects, on water quality, whereas Alternative 3 would have negligible positive effects on water quality.	Undetectable for all alternatives
Salmon and Steelhead	Mixed (negligible to moderate negative, to low positive) due to ESA compliance and development, habitat restoration, harvest, and fishery management practices, depending on species	Mixed (moderate negative to low positive), depending on species	Alternative 1 and Alternative 2 – Negligible to high negative genetics, competition, predation, facility operations, masking, incidental fishing, and disease transfer effects; and negligible to moderate positive population viability and nutrient cycling effects, depending on species.	Undetectable
			Alternative 3 – All negative and positive effects would be eliminated.	Negligible positive depending on species
			Alternative 4 – Same as Alternative 1 and Alternative 2, except that the negative genetics, competition, predation, facility operations, masking, incidental fishing, and disease transfer effects would be reduced, and the positive effects on population viability and nutrient cycling would be reduced.	Undetectable to negligible negative and positive, depending on species

Table 50. Summary of the cumulative effects under the alternatives, continued.

Affected Resource	Baseline	Past, Present, and Reasonably Foreseeable Future Actions[1]	Effects of the Alternatives[2]	Effects of the Alternatives on Cumulative Effects
Other Fish Species	Mixed (negligible negative to negligible positive) depending on species	Negligible to low negative depending on species	Mixed (negligible negative to negligible positive) depending on species	Undetectable
Wildlife – Southern Resident Killer Whale	Low positive due to ESA compliance	Low positive	Negligible positive	Undetectable
Socioeconomics	Moderate positive	Low positive	Alternative 1 and Alternative 2 – low positive	Negligible positive
			Alternative 3 - low negative	Negligible negative
			Alternative 4 - negligible positive	Undetectable to negligible negative to positive
Environmental Justice	Low negative to low positive	Low negative	Alternative 1 and Alternative 2 – moderate positive	Negligible positive
			Alternative 3 – moderate negative	Negligible negative
			Alternative 4 – moderate positive	Undetectable to negligible negative to positive
Human Health	Negligible negative	Negligible negative	Alternative 1, Alternative 2, and Alternative 4 - negligible negative Alternative 3 – negligible positive	Undetectable

[1] From Table 44.

[2] From Chapter 4 of this EIS.

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Chapter 6

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Chapter 7

7 DISTRIBUTION LIST

Federal and State Agencies

U.S. Army Corps of Engineers, (Seattle District)
U.S. Department of the Interior, Bureau of Indian Affairs
U.S. Environmental Protection Agency, Region 10
U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office
Washington Governor's Salmon Recovery Office
Washington Department of Fish and Wildlife, Olympia Office
Puget Sound Partnership

Elected Officials

U.S. Representatives, Washington State
U.S. Senators, Washington State

Utilities

Puget Sound Energy
Seattle City Light
Tacoma Public Utilities

Puget Sound and Olympic Peninsula Native American Tribes

Jamestown S'Klallam Tribe
Lower Elwha Klallam Tribe
Lummi Indian Nation
Makah Indian Tribe
Muckleshoot Indian Tribe
Nisqually Indian Tribe
Nooksack Indian Tribe
Port Gamble S'Klallam Tribe

Puyallup Tribe
Sauk-Suiattle Indian Tribe
Skokomish Tribe
Skagit System Cooperative
Snoqualmie Tribe
Squaxin Island Tribe
Stillaguamish Tribe of Indians
Suquamish Tribe
Swinomish Indian Tribal Community
Tulalip Tribes
Upper Skagit Tribe

Councils and Commissions

Columbia River Inter-tribal Fish Commission
Hood Canal Coordinating Council
Northwest Indian Fisheries Commission
Northwest Power and Conservation Council
Pacific Fishery Management Council
Pacific Salmon Commission
Pacific States Marine Fisheries Commission
Point No Point Treaty Council

Organizations and Associations

American Rivers
Building Industry Association of Washington
Center for Biological Diversity
Coastal Conservation Association, Washington
Earth Justice
Fishing Vessel Owner's Association
Long Live the Kings
Marine Conservation Biology Institute
Native Fish Society
Northwest Sportfishing Industry Association
NW Energy Coalition
Ocean Conservancy
Pacific Biodiversity Institute
Pacific Coast Federation of Fishermen's Associations
Pacific Rivers Council

People for Puget Sound
Puget Sound Anglers
Seattle Audubon Society
Sierra Club
Steelhead Trout Club of Washington
The Conservation Angler
The Mountaineers
Trout Unlimited
Washington Association of Realtors
Washington Environmental Council
Washington State Council of the Federation of Fly Fishers
Washington State Farm Bureau
Wild Fish Conservancy
Wild Salmon Center
Wild Steelhead Coalition

Libraries

King County Library System, Bellevue
Pierce County Library
Seattle Public Library, Main Library
Tacoma Public Library
Washington State Library

Individuals

(An extensive distribution list of individuals were notified by email that contained an electronic link to the EIS.)

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Chapter 8

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- NMFS Sustainable Fisheries Division (Rob Jones on hatchery production and salmon and steelhead, Craig Busack and Morgan Robinson on genetics)
- NMFS Protected Resources Division (Lynne Barre and Teresa Mongillo on Southern Resident killer whales)
- WDFW (Teresa Scott on water quantity, Brodie Antipa on facilities, Catie Mains on carcasses)

During development of the EIS, NMFS also consulted with the following tribes, organizations, and individuals:

- Jamestown S'Klallam Tribe (Scott Chitwood on tribal resources)
- Lower Elwha Klallam Tribe (Doug Morrill on tribal resources)
- Lummi Nation (Alan Chapman, Randy Kinley, and Merle Jefferson on tribal resources)
- Muckleshoot Indian Tribe (Isabel Tinoco, Dennis Moore, and Holly Coccoli on tribal resources)
- Nisqually Tribe (David Troutt on tribal resources)
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- Swinomish Indian Tribal Community (Brian Cladoosby on tribal resources)
- Tulalip Tribes (Mike Crewson on tribal resources)
- Upper Skagit Tribe (Jennifer Washington on tribal resources)

Chapter 9

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Appendix A

Puget Sound Salmon and Steelhead Hatchery Programs and Facilities

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Table A-1. Chinook hatchery programs and facilities.

Salmon Species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Chinook salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Chinook	Georgia Strait	Nooksack	**Skookum Creek Hatchery South Fork Early Chinook (August 2015)**	SF Nooksack	Spring	Integrated recovery	Conservation	Lummi Indian Nation	Subyearling/ May	1,000,000[a]	Skookum Creek Hatchery	SF Nooksack RM 14.3, tributary to the mainstem Nooksack River at RM 36.6
Chinook	Georgia Strait	Nooksack	**Kendall Creek Hatchery NF Nooksack Native Chinook Restoration (September 2014)**	NF Nooksack	Spring	Integrated recovery	Conservation	WDFW	Subyearling/ April-May	800,000	Kendall Creek Hatchery	Kendall Cr Hatchery, NF Nooksack RM 46; NF Nooksack in the vicinity of Boyd Cr RM 63; McKinnon Pond on the MF Nooksack RM 5.
Chinook	Georgia Strait	Nooksack	Lower Nooksack Fall Chinook (August 2015)	Green R. lineage (out-of-ESU)	Summer/ Fall	Isolated harvest	Harvest augmentation	Lummi Indian Nation	Subyearling/ May	2,000,000	Lummi Bay Hatchery	Lummi Bay (1.0 million) and Bertrand Creek, tributary to the Nooksack River at RM 1.5 (1.0 million)
Chinook	Georgia Strait	Nooksack	Samish Hatchery fall Chinook (November 2014)	Green R. lineage (out-of-ESU)	Summer/ Fall	Isolated harvest	Harvest augmentation	WDFW	Subyearling/ May	6,000,000[a]	Samish Hatchery	Samish River RM 10.5
Chinook	Georgia Strait	San Juan Islands (Orcas)	Glenwood Springs Hatchery (July 2016)	Green R. lineage (out-of-ESU)	Summer/ Fall	Isolated harvest	Harvest augmentation	Long Live The Kings	Subyearling/ July	725,000	Glenwood Springs Hatchery	Eastsound, Orcas Island (One HGMP)
Chinook	Whidbey Basin	Skagit	**Marblemount spring Chinook (2015-pending)**	Cascade	Spring	Isolated harvest	Indicator stock/ Harvest augmentation	WDFW	Subyearling/ June	587,500	Marblemount Hatchery	Cascade River, tributary to the Skagit River at RM 78.5
Chinook	Whidbey Basin	Skagit	**Marblemount summer Chinook (2015-pending)**	Upper Skagit	Summer	Integrated research	Indicator stock	WDFW	Subyearling/ May	200,000	Marblemount Hatchery	Countyline Ponds, Skagit River mainstem RM 91
Chinook	Whidbey Basin	Stillaguamish	**Stillaguamish Summer Chinook Natural Stock Restoration (draft September 2015)**	NF Stillaguamish	Summer	Integrated recovery	Conservation	WDFW	Subyearling/ April-May	220,000	Whitehorse Pond	Whitehorse Spring Ck (RM 1.5); trib to NF Stillaguamish at RM 28
Chinook	Whidbey Basin	Stillaguamish	**Stillaguamish Fall Chinook Natural Stock Restoration (draft September 2015)**	SF Stillaguamish	Fall	Integrated recovery	Conservation	Stillaguamish Tribe	Subyearling/ May	200,000	Harvey Creek Hatchery	Brenner Hatchery, SF Stillaguamish River RM 31.0

Salmon Species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Chinook salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Chinook	Whidbey Basin	Snohomish	**Bernie Kai-Kai Gobin Salmon Hatchery "Tulalip Hatchery" Subyearling Program (December 2012)**	Skykomish	Summer/ Fall	Integrated harvest	Harvest augmentation	Tulalip Tribes	Subyearling/ May	2,400,000	Bernie Kai-Kai Gobin Salmon Hatchery	Tulalip Bay, Port Susan
Chinook	Whidbey Basin	Snohomish	**Wallace River summer Chinook (February 2013)**	Skykomish	Summer	Integrated harvest	Harvest augmentation	WDFW	Subyearling/ June	1,000,000	Wallace River Hatchery	Wallace River RM 4.0, tributary to Skykomish River at RM 36
									Yearling/ April	500,000	Wallace River Hatchery	Wallace River RM 4.0, tributary to Skykomish River at RM 36
Chinook	Central/South Sound	Lake Washington	**Issaquah Hatchery fall Chinook (2015-pending)**	Sammamish	Fall	Integrated harvest	Harvest augmentation	WDFW	Subyearling/ May-June	2,000,000	Issaquah Hatchery	Issaquah Creek RM 3.0, tributary to Lake Sammamish
Chinook	Central/South Sound	Kitsap Peninsula	Grovers Creek Hatchery and Satellite Rearing Ponds (March 2013)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest augmentation	Suquamish Tribe	Subyearling/ May-June	420,000	Grovers Creek	Grovers Creek
									Subyearling/ May-June	100,000	Grovers Creek Hatchery/Gorst Creek Rearing Ponds	Dogfish Creek (Webster's) Rearing Ponds
									Subyearling/ May	1,600,000	Grovers Creek Hatchery/Gorst Creek Rearing Ponds	Gorst Creek Rearing Pond
Chinook	Central/ South Sound	Duwamish/ Green	**Soos Creek fall Chinook (April 2013)**	Green	Fall	Integrated harvest	Harvest augmentation	WDFW	Subyearling/ June	3,200,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33
									Subyearling/ June	1,000,000	Palmer Ponds	Green River RM 56.1
									Yearling/ April	300,000	Soos Creek /Icy Creek Pond	Icy Creek, tributary to the Green River at RM 48.3

Salmon Species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Chinook salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Chinook	Central/ South Sound	Duwamish/ Green	**Fish Restoration Facility (FRF) Green River Fall Chinook (July 2014) - replaces Keta Creek fall Chinook (July 2014)**	Green	Fall	Integrated harvest	Harvest augmentation/ research	Muckleshoot Tribe	Subyearling/ June	600,000 or below	FRF	Green River mainstem at RM 60
									Fry/ March-May	?	FRF	Green River watershed tributaries upstream of Howard Hanson Dam, located at RM 64
									Subyearling / June	?		
Chinook	Central/ South Sound	Puyallup	**Voights Creek fall Chinook program (April 2013)**	Puyallup	Fall	Integrated harvest	Harvest augmentation	WDFW	Subyearling/ June	1,600,000	Voights Creek Hatchery	Voights Creek (RM .5), trib to Carbon River at RM 4.0, trib to Puyallup River at RM 17.8
Chinook	Central/ South Sound	Puyallup	**Clarks Creek Fall Chinook (November 2012)**	Puyallup	Fall	Integrated harvest	Harvest augmentation	Puyallup Tribe	Subyearling/ April-May	1,000,000	Clarks Creek	Clarks Creek RM 0.8, tributary to Puyallup River at RM 5.8; Acclimation Ponds in Upper Puyallup River watershed (Puyallup RM 31-49 - includes Rushingwater Ck, Mowich R., and Cowskull Ck.); W.F. Hylebos Creek RM 1.0
										200,000	Upper Puyallup Acclimation Ponds	
										20,000	Hylebos Creek	
Chinook	Central/ South Sound	White	**White River Hatchery (spring Chinook) (December 2014)**	White	Spring	Integrated recovery	Conservation	Muckleshoot Tribe	Subyearling/ Late April - June	340,000	White River Hatchery	White River RM 23.4
									Yearling/ April	55,000	White River Hatchery	White River RM 23.4
									Subyearling/ June	1,300,000	White River Acclimation Ponds	Acclimation Ponds on the Greenwater R (trib to White River at RM 35.3), Huckleberry Creek (trib at RM 53.1), Cripple Creek (trib to W Fork White at RM 2), Jensen Creek, and Twenty-eight Mile Creek.

Salmon Species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Chinook salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Chinook	Central/ South Sound	Carr Inlet/South Sound	**Minter Creek/ Hupp Springs Hatchery White River spring Chinook (July 2016-pending 2017 update)**	White	Spring	Isolated recovery	Conservation/ Harvest	WDFW	Subyearling/ May	400,000	Hupp Springs Hatchery	Hupp Springs Hatchery on Minter Creek RM 3.0, tributary to Carr Inlet, South Puget Sound
Chinook	Central/ South Sound	Carr Inlet/South Sound	**~~Minter Creek/ Hupp Springs - White River spring Chinook yearling (August 2002)~~**	White	Spring	Isolated recovery	Conservation/ Harvest	WDFW	Yearling/ April	0	Hupp Springs Hatchery	Hupp Springs Hatchery on Minter Creek RM 3.0, tributary to Carr Inlet, South Puget Sound
Chinook	Central/ South Sound	Carr Inlet/South Sound	Minter Creek Hatchery fall Chinook (March 2017)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest augmentation	WDFW	Subyearling/ May	1,400,000	Minter Creek Hatchery	Minter Creek RM 0.5, tributary to Carr Inlet, South Puget Sound
Chinook	Central/ South Sound	Chambers Creek, South Puget Sound	Chambers Creek fall Chinook (May 2015)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest augmentation	WDFW	Subyearling/ April-May	450,000	Garrison Springs Hatchery	Chambers Creek Fishway Trap RM 0.5
									Subyearling/ May	400,000	Chambers Creek Hatchery	Chambers Creek Fishway Trap RM 0.5
Chinook	Central/ South Sound	Nisqually	**Nisqually Fish Hatchery at Clear Creek/Kalama Creek Salmon Hatchery (Nov 2016 draft - update pending)**	Nisqually	Fall	Segregated Harvest /Integrated harvest	Harvest augmentation (two stage integrated harvest)	Nisqually Tribe	Subyearling/ May-June (segregated component)	3,400,000	Clear Creek Hatchery	Clear Creek, tributary to Nisqually River at RM 6.3, RM 0.2 of Clear Creek.; McAllister Creek, tributary to the Nisqually River estuary at RM 5.5 on McAllister Creek
									Subyearling/ May-June (integrated component)	600,000	Kalama Creek Hatchery	Kalama Creek, tributary to Nisqually River at RM 9.2, RM 0.2 of Kalama Creek
Chinook	Central/ South Sound	Deschutes	Tumwater Falls fall Chinook (May 2013)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest augmentation	WDFW	Subyearling/ March-June	3,800,000	Tumwater Falls Hatchery	Deschutes River RM 0.2
Chinook	Hood Canal	Skokomish	**George Adams fall Chinook (November 2014)**	Skokomish	Fall	Integrated harvest	Harvest augmentation	WDFW	Subyearling/ May-June	3,800,000	George Adams Hatchery	Purdy Creek RM 1.8, tributary to the Skokomish River ay RM 4.0

Salmon Species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Chinook salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Chinook	Hood Canal	Skokomish	North Fork Skokomish River spring Chinook (March 2015)	Cascade	Spring	Integrated harvest	Harvest augmentation	Tacoma Power in cooperation with WDFW and the Skokomish Tribe	Subyearling/ summer-fall	300,000	North Fork Skokomish Hatchery	North Fork Skokomish River at RM 8.3, tributary to the Skokomish River at RM 9
									Yearling/ spring	75,000		
Chinook	Hood Canal	Finch Creek, west Hood Canal	Hoodsport fall Chinook (July 2014)	Green R. lineage (out-of-ESU)	Fall	Isolated harvest	Harvest augmentation	WDFW	Subyearling/ June	3,000,000	Hoodsport Hatchery	Finch Creek RM 0.0, tributary to west Hood Canal
									Yearling/ May	120,000	Hoodsport Hatchery	Finch Creek RM 0.0, tributary to west Hood Canal
Chinook	Strait of Juan de Fuca	Dungeness	**Dungeness River spring Chinook (January 2013)**	Dungeness	Spring	Integrated recovery	Conservation	WDFW	Subyearling/ May-June	150,000	Dungeness and Hurd Creek	Upper Dungeness River RM 15.8; Gray Wolf Acclimation Ponds RM 1.0; Dungeness River RM 10.5
									Yearling/ April	50,000	Hurd Creek Hatchery	Dungeness River RM 3.0
Chinook	Strait of Juan de Fuca	Elwha	**Elwha River summer/fall Chinook (November 2012)**	Elwha	Summer/ Fall	Integrated recovery	Conservation	WDFW	Subyearling/ June	2,500,000	Elwha Channel	Elwha River RM 3.5
									Yearling/ March-April	200,000	Elwha Channel	Elwha River RM 3.5

[a] Numbers are maximum release levels using current facilities as analyzed in the associated EIS. Release numbers shown do not reflect maximum levels described in HGMPs that that would require new facilities.

Table A-2. Steelhead hatchery programs and facilities.

Salmon Species	Steelhead major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Steelhead population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Steelhead	Northern Cascades	Nooksack	Kendall Creek Hatchery Winter Steelhead (July 2014)	Chambers Ck lineage (out-of-DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/ April-May	150,000	Kendall Creek Hatchery	NF Nooksack RM 46
Steelhead	Northern Cascades	Skagit	**Baker River: Steelhead Reservoir Passage Research (August 2015)**	Skagit River	Winter	Integrated research	Research	Upper Skagit Indian Tribe	Yearling/ May	11,000	Marblemount Hatchery	Baker Lake
Steelhead	Northern Cascades	Stillaguamish	Whitehorse Pond Summer Steelhead Program (draft 2014)	Skamania Hatchery-lineage (out-of-DPS)	Summer	Isolated harvest	Harvest augmentation	WDFW	Yearling/ April-May	70,000	Whitehorse Pond	Whitehorse Spring Ck RM 1.5, tributary to NF Stillaguamish at RM 28
Steelhead	Northern Cascades	Stillaguamish	Whitehorse Pond Winter Steelhead Program (July 2014)	Chambers Ck lineage (out-of-DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/ April-May	130,000	Whitehorse Pond	Whitehorse Spring Ck RM 1.5, tributary to NF Stillaguamish at RM 28
Steelhead	North Cascades	Snohomish/ Skykomish	Reiter Pond Summer Steelhead Program (draft 2013)	Skamania Hatchery-lineage (out-of-DPS)	Summer	Isolated harvest	Harvest augmentation	WDFW	Yearling/ April-May	190,000	Reiter Ponds	Reiter Pond 140K (RM 45); NF Skykomish @ Index 10K; Sultan R. 20K; Raging R. 50K
Steelhead	Northern Cascades	Snohomish/ Skykomish	Skykomish River Winter Steelhead Hatchery Program (February 2016)	Chambers Ck lineage (out-of-DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/ April-May	140,000	Reiter Ponds	Reiter Pond at Skykomish River RM 46
									Yearling/ April-May	27,600	Wallace Hatchery	Wallace River RM 4.0, tributary to Skykomish at RM 36
Steelhead	Northern Cascades	Snohomish/ Snoqualmie	Tokul Creek Winter Steelhead Program (July 2014)	Chambers Ck lineage (out-of-DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/ April-May	74,000	Tokul Creek Hatchery	Tokul Creek (RM 0.5), tributary of the Snoqualmie River at RM 39, tributary to the Snohomish River at RM 20.5
Steelhead	Northern Cascades	Green	Soos Creek (Green River) Hatchery Summer Steelhead (Oct 2015)	Skamania Hatchery-lineage (out-of-DPS)	Summer	Isolated harvest	Harvest augmentation	WDFW	Yearling/ April	50,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33.5
									Yearling/ April	50,000	Icy Creek Pond	Icy Creek, tributary to the Green River at RM 48.3

Salmon Species	Steelhead major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Steelhead population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Steelhead	Northern Cascades	Green	Green River Native Winter (late) Steelhead (Oct 2014)	Green River	Winter	Integrated recovery	Conservation	WDFW	Yearling/ May	18,000	Soos & Icy Creek Pond	Icy Creek, tributary to the Green River RM 48.3
									Yearling/ May	15,000	Soos & Flaming Geyser (Pond)	Flaming Geyser Park, Cristy Creek, tributary to the Green River at RM 44.3
Steelhead	Central and South Puget Sound	Green	**Fish Restoration Facility (FRF) Green River Winter Steelhead (July 2014)**	Green River	Winter	Integrated Recovery	Harvest Augmentation	Muckleshoot Indian Tribe	Yearling/ July	350,000 or below	FRF	Green River mainstem at RM 60
									Fed Fry/ July	?	FRF	Green River watershed tributaries upstream of Howard Hanson Dam, located at RM 64
									Yearling/ July	?		
Steelhead	Central and South Puget Sound	White	**White River Winter Steelhead Supplementation Program (November 2015)**	White River	Winter	Integrated recovery	Conservation	Puyallup Indian Tribe and Muckleshoot Indian Tribe w/ WDFW	Yearling/ May	60,000	Diru Creek Hatchery and White River Hatchery	White River RM 24.3. White River (from acclimation pond(s) on Clearwater, Greenwater, or Huckleberry Cr tributaries upstream of Mud Mt Dam RM 29.6).
Steelhead	Hood Canal and Strait of Juan de Fuca	Skokomish	**Hood Canal Steelhead Supplementation Project (April 2014)**	Skokomish River	Winter	Integrated recovery	Conservation	Long Live the Kings	Yearlings/ April-May	21,600	McKernan Hatchery	SF Skokomish River
										6,000	LLTK Lilliwaup Hatchery	SF Skokomish River
		Dewatto							Yearlings/ April-May	7,400		Dewatto River

Salmon Species	Steelhead major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Steelhead population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
				Eastside Hood Canal Tributaries					Adults/ March-April	253	LLTK Lilliwaup Hatchery	Dewatto River
		Duckabush		Westside Hood Canal Tributaries					Yearlings/ April-May	6,667	LLTK Lilliwaup Hatchery	Duckabush River
									Adults/ March-May	230		Duckabush River
Steelhead	Hood Canal and Strait of Juan de Fuca	North Fork Skokomish River	**North Fork Skokomish River Winter Steelhead Program (April 2016 - draft)**	Skokomish River	Winter	Integrated recovery	Conservation	Tacoma Power	Yearling/ May	15,000 (225 adults)	North Fork Skokomish Salmon Hatchery	North Fork Skokomish River, Base of Dam #2, RM 8.3
Steelhead	Hood Canal and Strait of Juan de Fuca	Dungeness	Dungeness Winter Steelhead Program (July 2014)	Chambers Ck lineage (out-of-DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/ May	10,000	Dungeness Hatchery	Dungeness River RM 10.5
Steelhead	Hood Canal and Strait of Juan de Fuca	Elwha	**Lower Elwha Fish Hatchery (August 2012)**	Elwha River	Winter	Integrated recovery	Conservation	Lower Elwha Klallam Tribe	Yearling/ May	175,000	Lower Elwha Hatchery	Elwha River RM 1.25

Table A-3. Coho salmon hatchery programs and facilities.

Salmon Species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Coho salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Coho	Strait of Georgia	Nooksack	Skookum Hatchery Coho (Nov 2015)	Nooksack	Normal-timed	Isolated harvest	Harvest augmentation	Lummi Indian Nation	Yearling/ May-June	1,500,000[a]	Skookum Creek Hatchery	SF Nooksack RM 14.3, tributary to the mainstem Nooksack River at RM 36.6
Coho	Strait of Georgia	Nooksack	Lummi Bay Hatchery Coho (Nov 2015)	Nooksack	Normal-timed	Isolated harvest	Harvest augmentation	Lummi Indian Nation	Yearling/ April-May	1,500,000[a]	Lummi Bay Hatchery	Lummi Bay, north Puget Sound
Coho	Whidbey Basin	Skagit	Skagit Coho Program (Draft August 2015)	Skagit (Cascade) River	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/ June	250,000	Marblemount Hatchery	Cascade River Rm 1.0, tributary to the Skagit River at RM 78.5
Coho	Whidbey Basin	Skagit	Baker River Coho (Draft August 2015)	Skagit (Baker)	Normal-timed	Integrated Harvest	Harvest augmentation	WDFW	Fry/ May-June	160,000	Baker Lake Sulphur Cr Facility	Baker Lake, behind Upper Baker Dam, Baker River RM 9.1
									Yearling/ May-June	5,000	Baker Lake Sulphur Cr Facility	Baker Lake, behind Upper Baker Dam, Baker River RM 9.1
									Yearling/ May-June	55,000	Baker Lake Sulphur Cr Facility	Stress Relief Ponds on Baker River RM 0.7 (Baker River Fish Trap), tributary to Skagit River at RM 56.5
									Yearling/ May-June	5,000	Baker Lake Sulphur Cr Facility	Lake Shannon, behind Lower Baker Dam, Baker River RM 8.9
Coho	Whidbey Basin	Stillaguamish	Stillaguamish Coho Program (March 2004)	Stillaguamish	Normal-timed	Integrated harvest/recovery	Harvest augmentation/conservation	Stillaguamish Tribe	Yearling/ May-June	60,000	Harvey Creek Hatchery/North Fork/Johnson Creek Hatchery	Harvey Creek Hatchery RM 2.0 on Harvey/Armstrong Creek, trib to the Stillaguamish River at RM 15.3
Coho	Whidbey Basin	Snohomish	Tulalip Coho Program (March 2013)	Skykomish	Normal-timed	Integrated Harvest	Harvest augmentation	Tulalip Tribes	Yearling/ May-June	2,000,000	Bernie Kai-Kai Gobin Salmon Hatchery, Wallace River Hatchery	Tulalip Creek and Tulalip Bay, Port Susan
Coho	Whidbey Basin	Snohomish	Wallace River Coho Program (October 2013)	Skykomish	Normal-timed	Integrated Harvest	Harvest augmentation	WDFW	Yearling/ May	150,000	Wallace River Hatchery	Wallace River RM 4.0, tributary to Skykomish River at RM 36

Salmon Species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Coho salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Coho	Whidbey Basin	Snohomish	Everett Net Pen Coho Program (June 2013)	Skykomish	Normal-timed	Isolated harvest	Harvest augmentation	Everett Steelhead and Salmon Club	Yearling/ June	20,000	Wallace River Hatchery	Port of Everett Visitor's Dock, mouth of the Snohomish River on Port Gardner Bay.
Coho	Central/South Sound	Lake Washington	Issaquah Coho Program (December 2014)	Issaquah Creek (x Green River)	Normal-timed	Isolated harvest	Harvest augmentation	NWSSC-Laebugten	Yearling/ June	25,000	Issaquah Creek Hatchery	Port of Edmonds, Public Fishing Pier
						Integrated Harvest		WDFW	Yearling/ May	450,000	Issaquah Creek Hatchery	Issaquah Creek RM 3.0, tributary to Lake Sammamish
Coho	Central/South Sound	Green	Soos Creek Coho Program (July 2014)	Green	Normal-timed	Integrated Harvest	Harvest augmentation	WDFW	Yearling/ May	600,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33.5
						Isolated harvest		Trout Unlimited	Yearling/ June	30,000	Soos Creek Hatchery	Des Moines Marina, central Puget Sound
									Fry/ January	54,000	Miller Creek Hatchery	Des Moines Creek, various
									Fry/ January	33,000	Miller Creek Hatchery	Miller Creek, various
									Fry/ January	33,000	Miller Creek Hatchery	Walker Creek, various
Coho	Central/South Sound	Green	Keta Creek Complex (June 2017)	Green	Normal-timed	Integrated Harvest	Harvest augmentation	Muckleshoot Indian Tribe	Yearling/ May	1,000,000	Crisp Creek Ponds	Crisp Creek RM 1.1 Green R. tributary at RM 40.1
										1,000,000	Elliot Bay Netpens	Elliot Bay, Puget Sound
										50,000	Supplementation site	TBD in Green River watershed

Salmon Species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Coho salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Coho	Central/South Sound	Green	Fish Restoration Facility (FRF) Green River Coho (July 2014)	Green	Normal-timed	Integrated Harvest	Harvest augmentation	Muckleshoot Indian Tribe/ Suquamish Tribe	Yearling/ TBD	600,000 or below	FRF	Green River mainstem at RM 60
									Fed Fry/ TBD	?	FRF	Green River watershed tributaries upstream of Howard Hanson Dam, located at RM 64
									Yearling/TBD	?		
Coho	Central/South Sound	Green	Marine Technology Center Coho Program (November 2014)	Green	Normal-timed	Isolated harvest	Education	WDFW	Yearling/ May	10,000	Soos Creek Hatchery	Seahurst Park (on Puget Sound) in Burien, Washington
Coho	Central/South Sound	Puyallup	Voights Creek Coho Program (August 2016)	Puyallup (Voights Creek Hatchery)	Normal-timed	Integrated harvest	Harvest augmentation	WDFW	Yearling/ April,May	1,080,000	Voights Creek Hatchery	Voights Creek RM 0.5, tributary to Carbon River at RM 4.0, trib to Puyallup River at RM 17.8
Coho	Central/South Sound	Puyallup	Puyallup Acclimation Sites - Diru Creek Fall coho (May 2013)	Puyallup (Voights Creek Hatchery)	Normal-timed	Integrated recovery	Restoration	Puyallup Tribe	Yearling/ April-May	100,000	Diru Creek Hatchery	Mowich River Acclimation Pond, RM 0.2 on Mowich River; Cowskull Creek Acclimation Pond, RM 0.1 on Cowskull Creek, trib to Puyallup River at RM 44.8; Rushingwater Acclimation Pond, RM 0.5 on Rushingwater Creek, trib to Mowich River at RM 1.1
									Yearling/ May	200,000	Voights Creek Hatchery/ Puyallup Tribal Hatchery	Lake Kapowisin Net Pens
Coho	Central/South Sound	Carr Inlet	Minter Creek Coho (January 2013)	Minter Creek	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/ May-July	500,000	Minter Creek Hatchery	Minter Creek RM 0.5, tributary to northern Carr Inlet in south Puget Sound

Salmon Species	Chinook salmon major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Coho salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Coho	Central/South Sound	Nisqually	Kalama Creek Hatchery Fall Coho (April 2003)	Central/South Sound mix	Normal-timed	Isolated harvest	Harvest augmentation	Nisqually Tribe	Yearling/ April	400,000	Kalama Creek Hatchery	Kalama Creek, tributary to Nisqually River at RM 9.2
Coho	Central/South Sound	South Puget Sound	Squaxin Island/ South Sound Net Pens (July 2014)	Central/South Sound mix	Normal-timed	Isolated harvest	Harvest augmentation	Squaxin Island Tribes and WDFW	Yearling/ May-June	1,800,000	South Sound net-pens,	Peale Passage, deep South Puget Sound
Coho	Hood Canal	Skokomish	George Adams Coho Yearling Program (January 2013)	Mixed Puget Sound, localized to Skokomish River	Normal-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/ post April-15	300,000	George Adams Hatchery	Purdy Creek RM 1.0, tribuary to Skokomish River at RM 4.1
Coho	Hood Canal	Port Gamble Bay/ Little Boston Creek	Port Gamble Coho Net Pens (March 2003)	Big Quilcene River	Early-timed	Isolated harvest	Harvest augmentation	Port Gamble S'Klallam Tribe/USFWS	Yearling/ June	400,000	George AdamsHatchery, Port Gamble Net pens	Port Gamble Bay, northern Hood Canal
Coho	Hood Canal	Quilcene	Quilcene Coho Net Pen (March 2003)	Big Quilcene River	Early-timed	Isolated harvest	Harvest augmentation	Skokomish Tribe and USFWS	Yearling/ May	150,000	Quilcene NFH, Quilcene Bay Net pens	Quilcene Bay, northwestern Hood Canal
Coho	Hood Canal	Big Quilcene River	Quilcene National Fish Hatchery Coho Salmon Production Program (June 2010)	Big Quilcene River	Early-timed	Isolated harvest	Harvest augmentation	USFWS	Yearling/ April-May	406,000	Quilcene NFH	Big Quilcene River RM 2.8
Coho	Strait of Juan de Fuca	Dungeness	Dungeness River Coho (January 2013)	Dungeness-mixed origin	Early-timed	Isolated harvest	Harvest augmentation	WDFW	Yearling/ June	500,000	Dungeness Hatchery and Hurd Creek Hatchery	Dungeness River RM 10.5
Coho	Strait of Juan de Fuca	Elwha	Lower Elwha Fish Hatchery (August 2012)	Elwha	Normal-timed	Integrated harvest	Harvest augmentation	Lower Elwha Klallam Tribe	Yearling/ May	425,000	Lower Elwha Hatchery	Elwha River RM 0.3

Note: MPGs for coho salmon have not been designated. Unless otherwise noted, MPG names are for the Chinook salmon MPGs associated with the watershed, or coho salmon populations.
[a] Numbers are maximum release levels using current facilities as analyzed in the associated EIS. Release numbers shown do not reflect maximum levels described in HGMPs that that would require new facilities.

Table A-4. Pink salmon hatchery programs and facilities.

Salmon Species	Major population group	Watershed	Hatchery program name, HGMP date (in parentheses	Pink salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Pink	Pink salmon MPGs have not been designated. Chinook salmon MPG is Strait of Georgia	Nooksack	Whatcom Creek Pink Program (January 2013)	Nooksack (localized to release site)	Normal	Isolated harvest	Education/ Harvest augmentation	Bellingham Technical College/ WDFW	Fed fry/ April	500,000	Whatcom Creek Hatchery	Whatcom Creek RM 0.5, tributary to Bellingham Bay
Pink	Pink salmon MPGs have not been designated. Chinook salmon MPG is Hood Canal	Finch Creek (western Hood Canal)	Hoodsport Pink Salmon Program (January 2013)	Dungeness/ Dosewallips (localized to the release site)	Normal	Isolated harvest	Harvest augmentation	WDFW	Fed fry/ April	500,000	Hoodsport Hatchery	Finch Creek, western Hood Canal
Pink	Pink salmon MPGs have not been designated. Chinook salmon MPG is Strait of Juan de Fuca	Dungeness	Dungeness River Pink Salmon Program (January 2013)	Dungeness	Normal	Integrated Recovery	Conservation	WDFW	Fed fry/ Apirl	100,000	Hurd Creek Hatchery	Dungeness River RM 3.0
Pink	Pink salmon MPGs have not been designated. Chinook salmon MPG is Strait of Juan de Fuca	Elwha	Elwha River Pink Salmon Preservation and Restoration Program (August 2012)	Elwha	Normal	Integrated Recovery	Conservation	Lower Elwha Klallam Tribe (and WDFW)	Fed fry/ March	3,000,000	Lower Elwha Hatchery	Elwha River, RM 1.3

Note: MPGs for pink salmon have not been designated. MPG names are for the Chinook salmon MPGs associated with the watershed.

Table A-5. Sockeye salmon hatchery programs and facilities.

Salmon Species	Major population group	Watershed	Hatchery program name, HGMP date (in parentheses	Sockeye salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Sockeye	Baker River sockeye form a single ESU. No MPG.	Skagit/Baker	Baker River Sockeye Program (August 2015)	Baker River (ESU)	Early Summer	Integrated harvest	Conservation	WDFW	Unfed fry/ February-May	2,000,000	Baker Lake Spawning Beach #4	Baker Lake Spawning Beach #4, located at the mouth of Sulphur Creek
									Fed fry/ March-May	3,500,000	Baker Lake Sulphur Cr Facility	Baker Lake, behind Upper Baker Dam, Baker River RM 9.1
									Fed fry/ March-May	2,500,000	Baker Lake Sulphur Cr Facility	Lake Shannon, tailrace below hatchery
									Subyearling / November	330,000	Baker Lake Sulphur Cr Facility	Baker Lake, behind Upper Baker Dam, Baker River RM 9.1
									Yearling/ April	5,000	Baker Lake Sockeye Spawning Beach facilities	Baker Lake, behind Upper Baker Dam, Baker River RM 9.1
									Yearling/ April	5,000	Baker Lake Sulphur Cr Facility	Lake Shannon, tailrace below hatchery
Sockeye	NA	Lake Washington	Cedar River Sockeye Program (December 2014)	Lake Washington (localized Baker River stock)	Early Summer	Integrated harvest	Conservation /Harvest	WDFW	Fed fry/ January-May	34,000,00 0	Cedar River Hatchery	Cedar River RM 21.7, 13.5, and 2.1

1 **Table A-6. Fall and summer chum salmon hatchery programs and facilities.**

Salmon Species	Major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Chum salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Strait of Georgia	Nooksack	Whatcom Creek Chum Program (October 2014)	Nooksack	Fall	Isolated harvest	Education/ Harvest augmentation	Bellingham Technical College/WDFW	Fed fry/ May	2,000,000	Whatcom Creek Hatchery, Kendall Creek Hatchery	Whatcom Creek RM 0.5, tributary to Bellingham Bay
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Strait of Georgia	Nooksack	NF Noosack River Fall Chum Program (Jan 2016)	Nooksack	Fall	Integrated harvest	Harvest augmentation	Lummi Indian Nation/ WDFW	Fed fry/ April-May	1,000,000[a]	Kendall Creek Hatchery	Kendall Creek, tributary to NF Nooksack River RM 46
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Strait of Georgia	Nooksack	Lummi Bay Fall Chum (Nov 2015)	Nooksack	Fall	Isolated harvest	Harvest augmentation	Lummi Indian Nation/ WDFW	Fed fry/ April-May	2,300,000[a]	Lummi Bay Complex,	Lummi Bay, north Puget Sound
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Whidbey Basin	Skagit	Upper Skagit Hatchery (August 2015)	Skagit	Fall	Integrated harvest/ Education	Education/ Harvest augmentation	Upper Skagit Indian Tribe	Fed fry/ May	450,000	Upper Skagit Hatchery	Red Creek tributary to Skagit River at RM 22.9
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Whidbey Basin	Skagit	Chum Remote Site Incubator (August 2015)	Skagit	Fall	Integrated Recovery	Conservation	Sauk-Suiattle Indian Tribe	Fed fry/ April	125,000	Three Sauk River RSI sites.	Hatchery Creek, trib. To the Sauk River at RM 0.2; Lyle Creek at RM 0.5; and Unnamed Side Channel At RM 15

Salmon Species	Major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Chum salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Whidbey Basin	Stillaguamish	Stillaguamish (Harvey Creek) Chum Program (March 2003)	Stillaguamish	Fall	Integrated education	Education/ Harvest augmentation	Stillaguamish Tribe	Unfed and fed fry/ April-May	225,000	Harvey Creek Hatchery	Harvey Creek Hatchery RM 2.0 on Harvey/Armstrong Creek, trib to the Stillaguamish River at RM 15.3
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Whidbey Basin	Snohomish	Tulalip Bay Hatchery Chum (April 2013)	Walcott Slough (localized to release site)	Fall	Isolated harvest	Harvest augmentation	Tulalip Tribes	Fed fry/ May	8,000,000	Bernie Kai-Kai Gobin Salmon Hatchery	Battle Creek RM 0.3, Tulalip Bay, Port Susan
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Central/South Sound	Green	Keta Creek Hatchery (December 2014)	East Kitsap (localized)	Fall	Integrated harvest	Harvest augmentation	Muckleshoot Indian Tribe	Fed fry/ April-May	5,000,000	Keta Creek Hatchery	Crisp Creek RM 1.1, tributary to the Green River at RM 40.1
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Central/South Sound	East Kitsap	Cowling Creek Hatchery and Satellite Incubation and Rearing Facilities (March 2003)	Chico Creek (East Kitsap)	Fall	Integrated harvest	Harvest augmentation	Suquamish Tribe	Unfed fry/ April	600,000	Cowling Creek Hatchery	Dogfish Creek (Liberty Bay), Clear and Barker Creeks (Dyes Inlet), and Steele Creek (Burke Bay); all are East Kitsap tribs
									Fed fry/ May	1,200,000	Cowling Creek Hatchery	Cowling Creek, tributary to Miller bay, East Kitsap
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Central/South Sound	Puyallup	Diru Creek Winter Chum (May 2013)	Chambers Creek (localized)	Late Fall	Integrated harvest	Harvest augmentation	Puyallup Indian Tribe	Fed fry/ April-May	1,950,000	Diru Creek Hatchery (Puyallup Tribal Hatchery)	Diru Creek RM 0.25, tributary to Clarks Creek, trib to Puyallup River at RM 5.8

Salmon Species	Major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Chum salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Chum	Fall-run chum salmon MPGs have not been designated. Chinook salmon MPG is Central/South Sound	Carr Inlet	Minter Creek Chum Program (January 2013)	Elson Creek (Skookum Inlet), localized	Fall	Integrated harvest	Harvest augmentation	WDFW	Fed fry/ April	2,000,000	Minter Creek Hatchery	Minter Creek RM 0.5, tributary to northern Carr Inlet in south Puget Sound
Chum	Fall-run chum salmon MPGs have not been designated. Listed summer-run chum salmon population is Hood Canal. Chinook salmon MPG is Hood Canal.	Skokomish	McKernan Fall Chum Program (September 2013)	Finch Creek	Fall	Isolated harvest	Harvest augmentation	WDFW	Fed fry/ April	11,500,000	McKernan Hatchery, George Adams Hatchery	Weaver Creek RM 1.0, tributary to the Skokomish River at RM
									Fry/ May-June	1,500,000	Rick's Ponds (LLtK), George Adams	Skokomish River
Chum	Fall chum MPGs have not been designated. Listed summer chum population is Hood Canal. Chinook salmon MPG is Hood Canal.	Enetai Creek (south Hood Canal)	Enetai Hatchery Fall Chum (September 2013)	Walcott Slough/Quilcene (localized to release site)	Fall	Isolated harvest	Harvest augmentation	Skokomish Tribe	Fed fry/ April	3,200,000	Enetai Hatchery	Enetai Creek, tributary to south Hood Canal north of the Skokomish River
Chum	Fall chum MPGs have not been designated. Area includes listed Hood Canal summer chum population, and the Hood Canal Chinook MPG.	Finch Creek (west Hood Canal)	Hoodsport Fall Chum (September 2013)	Finch Creek	Fall	Isolated harvest	Harvest augmentation	WDFW	Fed fry/ April	12,000,000	Hoodsport Hatchery, George Adams Hatchery	Finch Creek, westside tributary to Hood Canal
Chum	Hood Canal. No MPGs for summer-run chum salmon	Lilliwaup Creek	**Lilliwaup Creek Summer Chum (October 1999)**	Hood Canal	Summer	Integrated recovery	Conservation	WDFW and LLTK	Fry	150,000	Lilliwaup Hatchery	Lilliwaup Creek RM 0.5

Salmon Species	Major population group	Watershed	Hatchery program name, HGMP date (in parentheses), and listing status [listed or proposed for listing stocks shown in bold]	Chum salmon population	Species run or race	Hatchery program type	Hatchery program purpose	Hatchery operator	Life stage and time of release	HGMP release number	Primary facility	Release location(s)
Chum	Fall-run chum salmon MPGs have not been designated. Area includes the listed Hood Canal summer-run chum salmon population, and the Hood Canal Chinook salmon MPG.	Port Gamble Bay (north Hood Canal)	Port Gamble Hatchery Fall Chum (March 2013)	Walcott Slough (localized to release site)	Fall	Isolated harvest	Harvest augmentation	Port Gamble S'Klallam Tribe	Fed fry/ April-May	475,000	Little Boston Hatchery	Little Boston Creek, Port Gamble Bay, north Hood Canal.
Chum	Fall-run chum salmon MPGs have not been designated. Chinook MPG is Strait of Juan de Fuca	Elwha	Lower Elwha Fish Hatchery (August 2012)	Elwha	Fall	Integrated recovery	Conservation	Lower Elwha Klallam Tribe	Fed fry/ March-April	450,000	Lower Elwha Hatchery	Elwha River RM 0.3

Note: MPGs for fall chum salmon have not been designated. Unless otherwise noted (for summer chum), MPG names are for the Chinook salmon associated with the watershed, or summer chum populations.

[a] Numbers are maximum release levels using current facilities as analyzed in the associated EIS. Release numbers shown do not reflect maximum levels described in HGMPs that that would require new facilities.

Appendix B

Socioeconomics

Prepared by TCW Economics

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This appendix describes the methods and data used to develop baseline (existing) conditions in Subsection 3.5 (Affected Environment) and to analyze socioeconomic effects of the project alternatives in Subsection 4.5 (Environmental Consequences) of the EIS for 10 salmon and steelhead hatcheries in the Duwamish-Green River Basin. The development of baseline conditions is based on historical hatchery production levels and catch and effort conditions. The analysis of socioeconomic effects of changes in catch and effort under the project alternatives is based on estimated changes in hatchery production levels and associated effects on catch and effort relative to the baseline conditions and other alternatives.

Overview of Assessment Methods

The estimates of socioeconomic effects of predicted catch and fishing effort in Puget Sound commercial and recreational fisheries associated with salmon and steelhead production at the Duwamish-Green River Basin hatcheries are expressed in terms of economic value to commercial and recreational fishers and contribution to regional economic activity associated with hatchery production levels, catch, and fishing effort throughout the Puget Sound region (the socioeconomic analysis area for the EIS). Economic value to commercial fishers is measured in terms of ex-vessel value of the commercial catch, whereas economic value to recreational fishers is measured in terms of trip-related angler expenditures. These two socioeconomic metrics are key (but not the only important) indicators of economic value. Metrics of regional economic impacts, including employment and personal income, are key indicators of economic activity and describe the distributional effects of changes in economic activity within local and regional economies. Estimates of personal income, which reflect the total wages and profits associated with the expenditures made by commercial fishers, processors, sport anglers and relevant support businesses, are also derived and used by the Pacific Fishery Management Council (PFMC) in its annual economic assessment of salmon allocation decisions.

The following analytical steps were conducted to characterize baseline socioeconomic conditions and to analyze socioeconomic effects of the project alternatives relative to the baseline conditions, focusing on fishing activity directed at salmon and steelhead produced at hatcheries in the Duwamish-Green River Basin and caught in commercial and recreational fisheries throughout the Puget Sound region. Information compiled on regional salmon and steelhead fishing activity throughout the Puget Sound region is presented was used as a baseline to compare alternative-specific catch and related economic effects. Lastly, the description of these analytical steps is followed by a list of key assumptions that were used in the analyses.

Step 1: Estimate numbers of catchable fish associated with different levels of hatchery production.

Estimates of annual production of salmon and steelhead produced under programs operated at hatchery facilities in the Duwamish-Green River Basin are shown in Table B-1.

Table B-1. Duwamish/Green River Basin hatchery programs described by HGMPs in the Proposed Action.

Hatchery program (date HGMP updated)	Species Produced	Operator	Program Type	Annual Release Level	Does facility exist under existing conditions?
Soos Creek fall Chinook (4-3-13)	Fall Chinook (listed)	WDFW	Integrated harvest	4,200,000 suby[1] 300,000 y[1]	Yes
Soos Creek coho (7-24-14)	Coho	WDFW	Integrated harvest	630,000 y 120,000 fry	Yes
Soos Creek summer steelhead (12-10-15)	Steelhead	WDFW	Isolated harvest	100,000 y	Yes
Keta Creek coho (with Eliott net pens) (6-22-17)	Coho	MIT[2] and Suquamish Tribe	Integrated harvest	2,050,000 y	Yes
Keta Creek chum (7-18-14)	Chum	MIT	Integrated harvest	5,000,000 fry	Yes
Marine Technology Center coho (9-17-14)	Coho	WDFW	Isolated harvest/education	10,000 y	Yes
Fish Restoration Facility (FRF): fall Chinook (7-29-14)	Chinook (listed)	MIT	Integrated harvest	600,000 suby below HH dam, or different mix if juvenile passage[3]	No
FRF: coho (7-21-14)	Coho	MIT	Integrated harvest	600,000 y below HH dam, or different mix if juvenile passage[3]	No
FRF: winter steelhead (12-17-14)	Steelhead (listed)	MIT	Integrated harvest	350,000 y below HH dam, or different mix if juvenile passage[3]	No
Green River native winter (late) steelhead (10-13-14)	Steelhead (listed)	WDFW	Integrated conservation	33,000 y	Yes

[1] suby = subyearlings; y = yearlings.
[2] Includes production identified in recently submitted HGMP.
[3] MIT = Muckleshoot Indian Tribe.
[4] Release levels, life stage, and release location will ultimately depend on the status of planned juvenile fish passage facilities at the USACE Howard Hanson Dam (HHD) and related assessments.

Current production at all hatchery facilities in the Duwamish-Green River Basin is 11,443,000 fish. Under the Proposed Action, in which the fish restoration facility (FRF) would be constructed, annual production of salmon and steelhead would expand up to 13,993,000 fish.

Chinook Salmon

The number of smolt and fry Chinook salmon that would be released from hatchery facilities in the Duwamish-Green River Basin would range from 4,500,000 under existing conditions, to 5,100,000 fish under Alternative 1 and Alternative 2 (Table B-2). The number of adult Chinook salmon resulting from operation of hatchery facilities in the Duwamish-Green River Basin would range from 19,395 fish under existing conditions to 21,861 fish under the Proposed Action with releases below the Howard Hanson Dam (HHD) (Table B-2). The total number of adult Chinook salmon harvested in commercial and recreational fisheries throughout the Puget Sound region and along the Washington Coast is estimated to range from 8,262 fish to 9,313 fish (Table B-2).

Table B-2. Estimate of annual adult Chinook salmon production and harvest by Duwamish/Green River Basin hatchery programs

	Fish Life Stage	Proposed Annual Release Number	Smolt/Fry to Adult Survival Rate[1]	Total Adult Production	Total Available for Harvest[2]	Total Available to PS and WA Coast Fisheries[3]
Hatchery/Program						
Soos Creek	Subyrlgs	3,200,000	0.438%	14,000	8,666	5,964
Palmer Ponds	Subyrlgs	1,000,000	0.438%	4,375	2,708	1,864
Icy Creek	Yearlings	300,000	0.340%	1,020	631	435
FRF-Release Above HHD Option	Fry	500,000	0.041%	206	127	88
	Smolt	100,000	0.411%	411	254	175
FRF-Release Below HHD Option	Smolt	600,000	0.411%	2,466	1,526	1,051
Production and Harvest by Alternative						
Existing Conditions				19,395	12,006	8,262
Alts.1A/2A (release below HHD)				21,861	13,532	9,313
Alts.1B/2B (release above HHD)				20,012	12,387	8,525

[1] Soos Creek Hatchery subyearling and yearling SAR estimates for brood years 2005-2010 from L. LaVoy, NMFS. FRF smolt and fry survival rate return from Muckleshoot Indian Tribe (personal communication with E. Warner August 12, 2016).

[2] Total adult production reduced by average percent of CWT Chinook salmon that escape fisheries and return to Soos Creek Hatchery and natural spawning areas for Brood Years: 2000-2004, Adult Return Years: 2004-2008: 38.1% of the total annual adult contribution to fisheries harvest and escapement (WDFW Soos Creek Hatchery HGMP 2013).

[3] CWT recoveries of Soos Creek Hatchery subyearling fall Chinook salmon in Puget Sound and Washington Coastal fisheries accounted for 68.82% of total recoveries in all fisheries (WDFW Soos Creek Hatchery HGMP 2013).

Coho Salmon

The number of smolt and fry coho salmon that would be raised at hatchery facilities in the Duwamish-Green River Basin would range from 2,810,000 to 3,410,000 fish, depending on construction and operation of the FRF for salmon and steelhead (Table B-3). The number of adult coho resulting from operation of hatchery facilities in the Duwamish-Green River Basin would range from 160,027 fish under existing conditions to 201,427 fish under the proposed action with release below the HHD (Table B-3). The total number of adult coho salmon harvested in commercial and recreational fisheries throughout the Puget Sound region and along the Washington Coast is estimated to range from 86,409 to 108,756 fish.

Table B-3. Estimate of annual adult coho salmon produced at Duwamish/Green River Basin hatcheries and harvested.

	Fish Life Stage	Proposed Annual Release Number	Smolt/Fry to Adult Survival Rate[1]	Total Adult Production	Total Available for Harvest[2]	Total Available to PS and WA Coast Fisheries[3]
Hatchery/Program						
Soos Creek	Smolt	600,000	4.000%	24,000	13,800	12,958
Des Moines Marina	Smolt	30,000	6.050%	1,815	1,044	980
Central Sound Creeks	Fry	120,000	0.719%	862	496	466
Keta Complex	Smolt	1,050,000	6.900%	72,450	41,659	39,118
FRF (Above HHD Option)	Fry	500,000	0.690%	3,450	1,984	1,863
	Smolt	100,000	6.900%	6,900	3,968	3,725
FRF (Below HHD Option)	Smolt	600,000	6.900%	41,400	23,805	22,353
Elliott Net-Pens	Smolt	1,000,000	6.050%	60,500	34,788	32,665
Marine Tech	Smolt	10,000	4.000%	400	230	216
Production and Harvest by Alternative						
Existing Conditions				160,027	92,016	86,403
Alts.1A/2A (release below HHD)				201,427	115,821	108,756
Alts.1B/2B (release above HHD)				170,377	97,967	91,991

[1] Average SARs from RMIS BY 2004-2011 smolt to adult fishery contribution and return data for Soos Creek Hatchery, Crisp Creek Hatchery, and the Elliott Bay Net-pens (M. Haggerty 9-7-16). FRF SARs from MIT (E. Warner 8-12-16). SAR for Marine Tech assumed to be same as Soos Creek; SAR for Des Moines Marine assumed to be same as Elliott Bay Net-Pens. Central Sound Creeks SAR from WDFW HGMP.

[2] Total adult production reduced by average percent of CWT coho salmon that escape fisheries and return to Soos Creek Hatchery for Brood Years: 2001-2005, Adult Return Years: 2004-2008: 42.5% of the total annual adult contribution to fisheries harvest and escapement (WDFW Soos Creek Hatchery Coho Salmon HGMP 2013).

[3] CWT recoveries of Soos Creek Hatchery coho salmon in Puget Sound and Washington Coastal fisheries accounted for 93.90% of total recoveries in all recent year fisheries (WDFW Soos Creek Hatchery Coho Salmon HGMP 2014).

Chum Salmon

The estimated run size of chum salmon produced at hatchery facilities in the Duwamish-Green River Basin would be 58,055 fish annually (Table B-4). Of the 50,985 fish estimated to be commercially harvested, 56 percent (28,836 fish) would be harvested in the Lower Green River fisheries.

Step 2. Allocate total catch by port area

To better understand the regional distributional effects of expected changes in harvest and fishing effort, the estimates of commercial and recreational catch was then allocated to port areas within the Puget Sound region and along the Washington Coast based on historical catch and landing information.

Chinook Salmon

Allocating Commercial (Tribal and Non-Tribal) Harvest to Port Areas
Estimated Chinook salmon catch (Table B-2) was assigned to different commercial port areas based on fiscal year (FY) 2007-2014 coded-wire tagged (CWT) Chinook salmon recovery data for Soos Creek Hatchery subyearling Chinook salmon by recovery location. The distribution of the Chinook salmon harvest to commercial port landings is presented in Table B-5. A "crosswalk" between catch reporting areas and landing locations is presented in Figure B-1.

Allocating Recreational Catch and Trips to Port Areas
Estimated Chinook salmon catch (Table B-2) also was assigned to different recreational port areas based on FY 2007-2014 expanded CWT Chinook salmon recovery data for Soos Creek Hatchery subyearling Chinook salmon by recovery location (RMIS data from L. LaVoy, NOAA Fisheries Sustainable Fisheries Division, pers. comm., July 22, 2016). The distribution of the Chinook salmon harvest to recreational port landings is presented in Table B-6.

Table B-4. Estimate of run sizes and harvest of chum salmon production by Duwamish/Green River Basin hatchery programs, 2001-2013.

			Commercial[1]								FW Sport[2]	
				Catch Reporting Area[3]								
Year	**Run Size**	**Green River Escapement**	**80B (Lower Green River)**	**10a**	**10**	**6b-9**	**6a**	**7-7a**	**6**	**4b-6c**	**(80B)**	**A10**
2001	83,418	5,031	53,456	261	24,416	0	0	17	0	237	287	246
2002	51,732	5,409	28,507	2,167	15,260	0	0	370	0	19	395	269
2003	61,302	3,701	43,851	835	12,611	0	0	301	3	0	360	528
2004	50,958	2,843	33,835	172	13,348	199	0	500	0	61	488	307
2005	29,468	2,281	18,673	297	7,579	234	0	372	0	32	152	71
2006	58,329	5,877	32,142	4,686	14,715	399	0	434	0	76	260	109
2007	64,899	5,527	39,557	3,495	15,935	70	0	168	0	147	295	189
2008	69,695	14,281	27,067	10,390	16,882	1	0	865	6	208	743	94
2009	23,481	3,244	9,071	5,069	5,673	281	0	132	1	10	485	59
2010	84,547	8,717	39,875	11,734	23,276	530	0	343	0	72	534	557
2011	52,145	9,990	16,469	7,520	17,658	16	0	442	0	50	987	39
2012	74,203	7,126	36,462	4,985	24,656	306	0	652	4	12	906	536
2013	48,182	4,001	19,980	10,079	13,707	64	0	334	0	17	1,133	156
2014	64,204	13,522	21,351	10,893	16,626	390	0	1280	27	115	540	243
2015	42,520	2,764	12,221	8,049	18,151	428	0	759	7	141	540	243
average	***58,055***	***6,288***	***28,834***	***5,375***	***16,033***	***195***	***0***	***465***	***3***	***80***	***540***	***243***
Percent of Run Size	**100.00%**	**10.83%**	**49.67%**	**9.26%**	**27.62%**	**0.34%**	**0.00%**	**0.80%**	**0.01%**	**0.14%**	**0.93%**	**0.42%**

[1] Commercial Catch Data Source - WDFW Puget Sound Chum Salmon Run Reconstruction Database - Personal conversation with A. Dufault, spring 2016.

[2] Sport Catch estimates of Green River chum salmon from WDFW Annual Sport Catch Data Reports - 2001-2013. Data for 2014 and 2015 were not available, so 2001-2013 averages are used for those years.

[3] Refer to Figure B-1 for catch reporting areas.

Table B-5. Average annual Chinook salmon commercial harvest distribution in Puget Sound/WA coastal fisheries resulting from hatchery production in the Duwamish/Green River Basin.

	Landing Location by Fishery																
	Seattle SW (All)	**Seattle SW (Tribes)**	**Neah Bay (Tribes)**	**Seattle FW (Tribes)**	**Bellingham (7B Tribes)**	**Sekiu (Tribes)**	**Tacoma (Tribes)**	**Sequim (Tribes)**	**Bremerton (Tribes)**	**WA Coast (Ilwaco NT)**	**WA Coast (Westport/ Lapush All)**	**WA Coast (Neah Bay NT)**	**Marysville/ Everett (All)**	**Kingston (Tribes)**	**Bham/ Blaine 7/7A All**	**Shelton/ Olympia Tribes**	**Total[1]**
Percent Harvest by Fishery[2]	0.098%	4.361%	3.677%	52.131%	0.07%	0.976%	0.033%	0.000%	0.000%	0.618%	2.050%	6.378%	0.000%	0.130%	0.000%	0.423%	70.9%
Harvest Distribution by Fishery (Numbers of Hatchery Fish) under Different Alternatives																	
Existing Conditions	8	360	304	4,307	5	81	3	0	0	51	169	527	0	11	0	35	5,861
Alts.1A/2A (release below HHD)	9	406	342	4,855	6	91	3	0	0	58	191	594	0	12	0	39	8
Alts.1B/2B (release above HHD)	8	372	313	4,444	6	83	3	0	0	53	175	544	0	11	0	36	9

[1] These percentages represent the share of the total harvest (commercial and recreational).

[2] Percentages derived by NMFS based on 2007-2015 CWT Chinook salmon recovery data for Soos Creek Hatchery subyearling Chinook salmon by recovery location.

Table B-6. Average annual Chinook salmon recreational catch and angler trips distribution in Puget Sound/WA coastal fisheries resulting from hatchery production in the Duwamish/Green River Basin.

	Seattle SW Sport	Neah Bay (Tribes Charter)	Seattle FW Sport	Bellingham (7B) Sport	Sekiu Sport	Tacoma Sport	Sequim/ Port Angeles Sport	Bremerton Sport	WA Coast (Ilwaco Sport)	WA Coast (Westport/ Lapush Sport)	WA Coast (Neah Bay Sport)	Marysville/ Everett Sport	Kingston Sport	Bham/ Blaine (7/7A) Sport	Port Townsend Sport	Shelton/ Olympia Sport	Total[1]
Percent Harvest by Fishery[2]	5.988%	0.390%	1.009%	0.000%	4.035%	1.985%	2.310%	0.000%	0.911%	0.944%	1.952%	3.254%	2.668%	2.929%	1.041%	0.000%	29.4%
Catch Distribution by Fishery (Numbers of Hatchery Fish) under Different Alternatives																	
Existing Conditions	495	32	83	0	333	164	191	0	75	78	161	269	220	242	86	0	2,431
Alts.1A/2A (release below HHD)	558	36	94	0	376	185	215	0	85	88	182	303	249	273	97	0	2,740
Alts.1B/2B (release above HHD)	510	33	86	0	344	169	197	0	78	80	166	277	227	250	89	0	2,508
Trips Distribution by Fishery (Numbers of Hatchery Fish) under Different Alternatives[3,4]																	
Existing Conditions	1,649	43	504	0	443	1,026	464	0	93	83	200	964	735	1,131	308	0	7,643
Alts.1A/2A (release below HHD)	1,858	48	568	0	499	1,157	523	0	104	94	225	1,086	828	1,275	348	0	8,615
Alts.1B/2B (release above HHD)	1,701	44	520	0	457	1,059	479	0	96	86	206	995	758	1,167	318	0	7,886

[1] These percentages represent the share of the total harvest (commercial and recreational).

[2] Percentages derived by NMFS based on FY 2007-2014 CWT Chinook salmon recovery data for Soos Creek Hatchery subyearling Chinook salmon by recovery location.

[3] FW Sport Angler Trip estimates based on Susan Bishop memo (September 17, 2013) reporting estimated angler success trips/fish for Puget Sound region freshwater salmon fisheries. Angler success trips/fish in 2006 and 2011 were 8.65 and 3.44, respectively, averaging 6.05.

[4] SW Sport Angler Trip estimates derived using recent year (2007-2014) average angler success trips per fish (all species pooled, Table c-cc) by Puget Sound Catch Reporting Area (annual data from E. Kraig, WDFW, September 7, 2016) applied to sport catch estimates for each marine area under the FRF release scenarios (Table C-2).

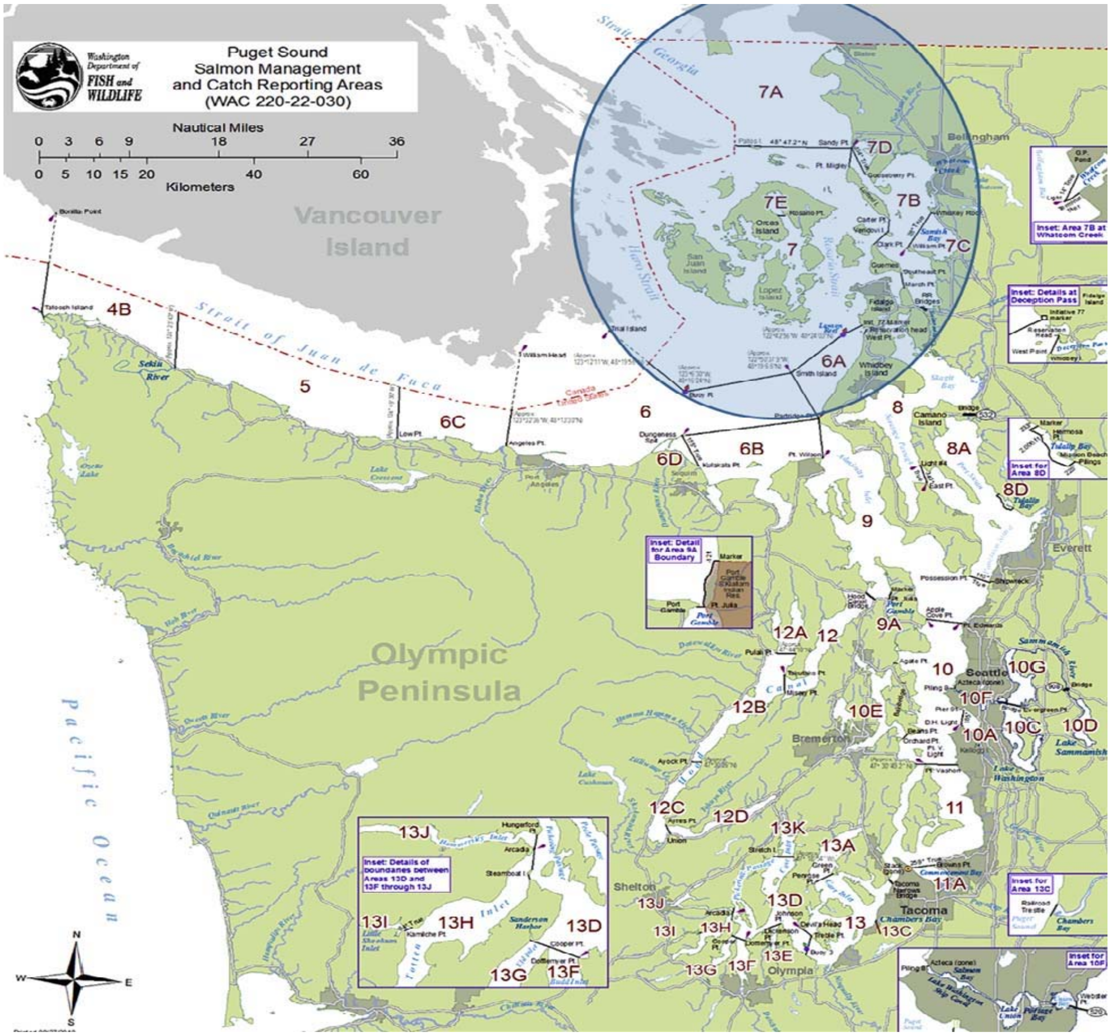

Figure B-1. Catch reporting areas and port landings in the Puget Sound region.

Estimates of recreational catch (Table B-6) were converted to angler trips using 2013 fishing success information compiled by NMFS (personal communication with Susan Bishop 2016). This conversion information is presented in Table B-7.

Table B-7. Average sport fishing success: trips per fish caught, by catch area.

Catch Reporting Area	2007-2014 Average
5	1.328824
6	2.432299
7	4.675821
8-1	6.490469
8-2	8.146946
9	3.585097
10	3.332331
11	6.257556
12	4.592557
13	12.694046
FW	6.045000

Source: NMFS (personal communication with Susan Bishop 2016)

Coho Salmon

Allocating Commercial (Tribal and Non-Tribal) Harvest to Port Areas

Estimated coho salmon catch (Table B-3) was assigned to different commercial port areas based on recoveries of Soos Creek hatchery coho salmon in Puget Sound and Washington coastal fisheries, which accounted for an average 93.90% of total recoveries in recent years (WDFW Soos Creek Hatchery coho Salmon HGMP 2014).

The distribution of the coho salmon harvest to commercial port landings is presented in Table B-8. A "crosswalk" between catch reporting areas and landing locations is presented in Figure B-1.

Allocating Recreational Catch to Port Areas

Estimated coho salmon catch (Table B-3) was assigned to different recreational port areas based on FY 2007-2014 expanded CWT coho salmon recovery data by location in Puget Sound and Washington coastal fisheries for Elliott Bay net-pen coho salmon (RMIS data from L. LaVoy, NOAA Fisheries Sustainable Fisheries Division, pers. comm., August 18, 2016. The distribution of the coho salmon harvest to recreational port landings is presented in Table B-9.

Table B-8. Average annual coho salmon commercial harvest distribution in Puget Sound/WA coastal fisheries resulting from hatchery production in the Duwamish/Green River Basin.

	Landing Location by Fishery																
	Seattle SW (All)	**Seattle SW (Tribes)**	**Neah Bay (Tribes)**	**Seattle FW (Tribes)**	**Bellingham (7B Tribes)**	**Sekiu (Tribes)**	**Tacoma (Tribes)**	**Sequim (Tribes)**	**Bremerton (Tribes)**	**WA Coast (Ilwaco NT)**	**WA Coast (Westport/ Lapush All)**	**WA Coast (Neah Bay NT)**	**Marysville/ Everett (All)**	**Kingston (Tribes)**	**Bham/ Blaine 7/7A All**	**Shelton/ Olympia Tribes**	**Total[1]**
Percent Harvest by Fishery[2]	5.59%	4.36%	0.48%	60.81%	0.02%	0.37%	0.44%	0.02%	0.01%	0.11%	0.24%	2.01%	0.18%	0.04%	0.05%	0.07%	74.8%
Harvest Distribution by Fishery (Numbers of Hatchery Fish) under Different Alternatives																	
Existing Conditions	4,832	3,765	415	52,538	14	322	382	17	9	94	209	1,737	153	34	47	65	64,632
Alts.1A/2A (release below HHD)	6,082	4,739	522	66,130	18	405	481	22	11	119	263	2,186	192	43	59	81	81,352
Alts.1B/2B (release above HHD)	5,144	4,008	442	55,936	15	343	407	18	10	100	222	1,849	163	36	50	69	68,812

[1] These percentages represent the share of the total harvest (commercial and recreational).

[2] Percentages derived by NMFS based on CWT recovery data for basin-origin fish by recovery location.

Table B-9 Average annual coho salmon recreational catch and angler trips distribution in Puget Sound/WA coastal fisheries resulting from hatchery production in the Duwamish/Green River Basin.

	Seattle SW Sport	Neah Bay (Tribes Charter)	Seattle FW Sport	Bellingham (7B) Sport	Sekiu Sport	Tacoma Sport	Sequim/ Port Angeles Sport	Bremerton Sport	WA Coast (Ilwaco Sport)	WA Coast (Westport / Lapush Sport)	WA Coast (Neah Bay Sport)	Marysville/ Everett Sport	Kingston Sport	Bham/ Blaine (7/7A) Sport	Port Townsend Sport	Shelton/ Olympia Sport	Total[1]
Percent Harvest by Fishery[2]	5.02%	0.39%	0.24%	0.01%	9.57%	0.48%	0.79%	0.00%	2.42%	0.23%	2.28%	2.54%	0.24%	0.05%	0.20%	0.00%	24.5%
Catch Distribution by Fishery (Numbers of Hatchery Fish) under Different Alternatives																	
Existing Conditions	4,339	334	211	8	8,267	417	684	0	2,092	194	1,973	2,196	209	42	172	0	21,13
Alts.1A/2A (release below HHD)	5,461	420	266	10	10,405	525	861	0	2,634	245	2,483	2,764	264	53	217	0	26,60
Alts.1B/2B (release above HHD)	4,619	355	225	9	8,801	444	728	0	2,228	207	2,100	2,338	223	45	183	0	22,50
Trips Distribution by Fishery (Numbers of Hatchery Fish) under Different Alternatives																	
Existing Conditions	14,458	444	1,275	38	10,985	2,612	1,664	0	2,574	208	2,446	7,873	698	198	617	0	46,08
Alts.1A/2A (release below HHD)	18,198	558	1,605	48	13,827	3,287	2,095	0	3,239	262	3,079	9,910	879	249	777	0	58,01
Alts.1B/2B (release above HHD)	15,393	472	1,358	40	11,696	2,781	1,772	0	2,740	221	2,604	8,383	743	210	657	0	49,07

[1] These percentages represent the share of the total harvest (commercial and recreational).

[2] Percentages derived by NMFS based on CWT recovery data for basin-origin fish by recovery location.

Chum Salmon

Allocating Commercial (Tribal and Non-Tribal) Harvest to Port Areas

Estimated chum salmon catch (Table B-4) was assigned to different fish reporting and port areas based on WDFW Puget Sound Chum Salmon Run Reconstruction Database - A. Default 2016.

The distribution of the chum harvest to commercial port landings is presented in Table B-10. A "crosswalk" between catch reporting areas and landing locations is presented in Figure B-1.

Allocating Recreational Catch to Port Areas

Estimated chum salmon catch (Table B-4) was assigned to different fish reporting and port areas based on WDFW Puget Sound Chum Salmon Run Reconstruction Database - A. Default 2016. The distribution of the chum salmon harvest to recreational port landings is presented in Table B-11. Recreational catch estimates for Green River chum salmon were derived from WDFW Annual Sport Catch Data Reports - 2001-2013. Because data for 2014 and 2015 were not available, the 2001-2013 averages were used in the calculation for these years. The results of this compilation are shown in Table B-11.

Table B-10. Average annual chum salmon commercial harvest distribution in Puget Sound/WA coastal fisheries resulting from hatchery production in the Duwamish/Green River Basin.

Commercial Fisheries Landing Locations								
Seattle (FW - MIT Comm)	**Seattle (SW - MIT + Suquam Comm)**	**Seattle-Everett Treaty/N-Treaty Comm**	**Port Townsend (PTPTT Comm)**	**Anacortes (Comm)**	**Bellingham-Blaine Treaty/N-Treaty Comm**	**Port Angeles (JTSKT-LEKT Comm)**	**Neah Bay-Sekiu (Makah Comm)**	**TOTAL**
40,479	7,546	22,508	273	-	652	4	112	71,575

Source: Commercial Catch Data Source - WDFW Puget Sound Chum Salmon Run Reconstruction Database - A. Dufault, spring 2016.

Table B-11. Average annual chum salmon recreational catch and angler trips distribution in Puget Sound/WA coastal fisheries resulting from hatchery production in the Duwamish/Green River Basin.

Recreational Chum Fisheries Landing Locations				
Seattle (FW Sport) Catch[1]	**Seattle (SW Sport) Catch[1]**	**Seattle (FW Sport) Angler Trips[2]**	**Seattle (SW Sport) Angler Trips[3]**	**TOTAL**
759	341	4,590	1,137	5,727

[1] Sport Catch estimates of Green River chum salmon from WDFW Annual Sport Catch Data Reports - 2001-2013. Data for 2014 and 2015 not yet available, so estimates for those years are the 2001-2013 averages: 6.05

[2] FW Sport Angler Trip estimate based on Susan Bishop memo (September 17, 2013) reporting estimated angler success trips/fish for Puget Sound region freshwater salmon fisheries. Angler success trips/fish in 2006 and 2011 were 8.65 and 3.44, respectively, averaging: 3.33

[3] SW Sport Angler Trip estimates for Area 10 derived using recent year (2007-2014) average angler success trips per fish (all species pooled) by Puget Sound Catch Reporting Area (annual data from E. Kraig, WDFW, September 7, 2016) applied to the chum salmon sport catch estimates for Area 10 (Seattle):

Step 4. Convert commercial catch and recreational trip estimates to relevant economic values

Step 4a. Convert number of fish landed in tribal and non-tribal commercial fisheries to ex-vessel values using average weights and prices.

Once estimated landings (in numbers of fish) by port area for each relevant species harvested by tribal and non-tribal commercial fishers were assigned to the corresponding relevant regions, the total harvested weight was calculated by multiplying landings by average weights for each species. These averages, which are shown in Table B-12, are based on 2015 data derived from WDFW's LIFT database.

Table B-12. Average per-fish weights (in pounds) used to convert estimated landings to ex-vessel weights.

Species	**Average Weight per Fish (pounds)**
Chinook salmon	10.8
Chum salmon	7.7
Coho salmon	6.4
Pink salmon	3.2
Sockeye salmon	4.6
Steelhead	7.1

Once harvested weights were calculated, the ex-vessel value of the commercial harvests in each region were estimated by multiplying harvested poundage by average price per pound for each species. These average prices, which are shown in Table B-13, were based on 2015 PacFIN data for Puget Sound area landings and ex-vessel revenue. The baseline number of 139,292 fish landed in

Tribal and non-tribal commercial fisheries had an estimated total landed weight of 1,014,384 pounds and received an estimated $885,868 in total ex-vessel revenue. Note that all dollar values are inflation-adjusted to $2015 using the Bureau of Economic Analysis' Gross Domestic Product implicit price deflator series.

Table B-13. Average prices (per pound) used to convert estimated harvested poundage to ex-vessel values.

Species	Average Price per Pound ($2015)
Chinook salmon	$2.44
Chum salmon	$0.64
Coho salmon	$0.99
Pink salmon	$0.24
Sockeye salmon	$1.40
Steelhead	$2.24

Step 4b: Convert sport fishing trips to trip-related spending

Information from the Input-Output Model for Pacific Coast Fisheries (IOPAC) used by NMFS for analyzing economic impacts of its annual salmon update indicates that average spending per trip in marine waters is estimated at $175.82 per (marine) angler-trip in the Puget Sound region. These per-trip spending estimates were multiplied by the number of sport fishing trips in each region to estimate total trip-related expenditures made by anglers targeting salmon and steelhead. The total of 53,856 baseline recreational angler trips was associated with an estimated $9.47 million in total trip-related expenditures (all dollar values are in inflation-adjusted $2015).

Step 5: Estimate regional economic impacts (employment and personal income) of the ex-vessel value of commercial landings and of recreational fishing-related trip expenditures

Regional economic impacts (REI), as measured in terms of personal income and employment (full-time equivalents, or FTEs) were estimated using factors developed by the Northwest Fisheries Science Center's IOPAC model. These factors, which incorporate information from the Impact Analysis for Planning (IMPLAN) modeling program, commercial landings data, survey-based industry cost data, and survey-based angler expenditure data, were applied to estimates of total tribal and non-tribal commercial ex-vessel values and recreational trip-related expenditures. A description of IOPAC fisheries economic impact model can be found at: https://www.nwfsc.noaa.gov/assets/25/1620_08012011_142237_InputOutputModelTM111WebFinal.pdf

The estimated total income impact attributable to combined commercial harvesting and primary processing per dollar of Puget Sound commercial ex-vessel salmon value is $1.66. Multiplying this value by the estimated baseline total ex-vessel salmon value ($885,868) results in an estimated total baseline personal income attributable to Puget Sound commercial (tribal and non-tribal) salmon fisheries of $1.47 million. For computing the regional economic effects of the affected recreational fisheries, average REI factors were applied to the estimated number of angler trips under baseline conditions and each alternative to estimate regional economic impacts (direct and indirect personal income and jobs). Application of the recreational REI factors to the estimated baseline number of angler trips (53,856) results in an estimated baseline of approximately $9.47 million in regional income attributable to Puget Sound recreational salmon fisheries, plus an additional $1.6 million derived from baseline hatchery operations (all dollar values are in inflation-adjusted $2015).

After calculating the income impacts under each alternative, employment attributable to commercial (tribal and non-tribal) fishing and processing and recreational salmon angling in Puget Sound area counties was estimated by dividing the corresponding income impact estimate for each region (county) by the average total earnings per job in each corresponding county derived from 2015 Bureau of Economic Analysis data (BEA Tables CA05N and CA25N). Application of average regional total earnings factors per job resulted in baseline employment estimates of 19 jobs, 171 jobs, and 18 jobs associated with total tribal and non-tribal commercial fisheries, recreational fisheries, and hatchery operations, respectively.

For report preparation, model outputs that were more detailed than needed for reporting purposes were aggregated, as appropriate.

Step 6. Compile catch and trip data to develop Puget Sound regional baseline conditions

In addition to considering the socioeconomic effects of the project alternatives relative to existing conditions associated with current salmon and steelhead hatchery production programs at the Duwamish-Green River Basin facilities, a ‘snapshot’ of Puget Sound-wide regional conditions associated with all salmon and steelhead fishing activity in the Puget Sound region between 2010 and 2014 was constructed. Average annual conditions were developed to characterize salmon and steelhead commercial fisheries, as measured by catch and ex-vessel value; salmon and steelhead recreational fisheries, as measured by angler trips and trip-related angler expenditures; and regional economic activity, as measured by jobs and amount of personal income generated by the economic activity associated with the salmon and steelhead fisheries in the Puget Sound region. The results of this characterization of regional baseline conditions concerning salmon and steelhead fishing activity in the Puget Sound region is presented in Table B-14.

Table B-14. Puget Sound regional baseline conditions concerning salmon and steelhead fishing activity, 2010–2014.

COMMERCIAL		**RECREATIONAL**		**REGIONAL ECON IMPACTS**	
Existing Conditions (2010-2014)		**Existing Conditions (2010-2014)**		**Existing Conditions (2010-2014)**	
Region	Number	Region	Number	Region	Number
North Puget Sound		North Puget Sound		North Puget Sound	
Whatcom County		Whatcom County		Whatcom County	
Non-Tribal		Catch (number of fish)		Commercial	
Harvest (number of fish)	2,140,340	Sport trips	30,144	Personal income	14,192,491
Ex-vessel harvest value	8,593,477	Expenditures	5,334,060	Jobs	286
Tribal		Skagit County		Sport	
Harvest (number of fish)	96,274	Catch (number of fish)		Personal income	4,780,257
Ex-vessel harvest value	748,779	Sport trips	40,188	Jobs	96
Total		Expenditures	7,111,356	Total	
Harvest (number of fish)	2,236,615	Snohomish County		Personal income	18,972,748
Ex-vessel harvest value	9,342,255	Catch (number of fish)		Jobs	382
Skagit County		Sport trips	342,431	Skagit County	
Non-Tribal		Expenditures	60,594,179	Commercial	
Harvest (number of fish)	776,728	Island County		Personal income	4,338,136
Ex-vessel harvest value	2,223,081	Catch (number of fish)		Jobs	86
Tribal		Sport trips	157,189	Sport	
Harvest (number of fish)	137,444	Expenditures	27,815,088	Personal income	6,141,561
Ex-vessel harvest value	632,512	Sna Juan County		Jobs	121
Total		Catch (number of fish)		Total	
Harvest (number of fish)	914,172	Sport trips	13,669	Personal income	10,479,698
Ex-vessel harvest value	2,855,593	Expenditures	2,418,774	Jobs	207
Snohomish County		North Puget Sound Region Total		Snohomish County	
Non-Tribal		Catch (number of fish)		Commercial	
Harvest (number of fish)	125,115	Sport trips	583,621	Personal income	1,469,226
Ex-vessel harvest value	774,581	Expenditures	103,273,457	Jobs	24
Tribal		South Puget Sound		Sport	
Harvest (number of fish)	25,434	King County		Personal income	48,482,813
Ex-vessel harvest value	192,542	Catch (number of fish)		Jobs	779
Total		Sport trips	410,233	Total	
Harvest (number of fish)	150,548	Expenditures	72,591,925	Personal income	49,952,039
Ex-vessel harvest value	967,123	Pierce County		Jobs	803
Island County		Catch (number of fish)		Island County	
Non-Tribal		Sport trips	214,563	Commercial	
Harvest (number of fish)	2,806	Expenditures	37,967,484	Personal income	47,830
Ex-vessel harvest value	27,023	Thurston County		Jobs	1
Tribal		Catch (number of fish)		Sport	
Harvest (number of fish)	486	Sport trips	59,104	Personal income	22,250,363
Ex-vessel harvest value	4,462	Expenditures	10,458,635	Jobs	358
Total		Mason County		Total	
Harvest (number of fish)	3,292	Catch (number of fish)		Personal income	22,298,193
Ex-vessel harvest value	31,484	Sport trips	35,675	Jobs	358
San Juan County		Expenditures	6,312,800	San Juan County	
Non-Tribal		Kitsap County		Commercial	
Harvest (number of fish)	9,451	Catch (number of fish)		Personal income	109,882

COMMERCIAL		RECREATIONAL		REGIONAL ECON IMPACTS	
Existing Conditions (2010-2014)		**Existing Conditions (2010-2014)**		**Existing Conditions (2010-2014)**	
Region	Number	Region	Number	Region	Number
Ex-vessel harvest value	69,109	Sport trips	130,522	Jobs	3
Tribal		Expenditures	23,096,181	Sport	
Harvest (number of fish)	186	South Puget Sound Region Total		Personal income	2,194,531
Ex-vessel harvest value	3,221	Catch (number of fish)		Jobs	65
Total		Sport trips	850,097	Total	
Harvest (number of fish)	9,637	Expenditures	150,427,025	Personal income	2,304,413
Ex-vessel harvest value	72,330	Strait of Juan de Fuca		Jobs	68
North Puget Sound Region Total		Clallam County		North Puget Sound Region Total	
Non-Tribal		Catch (number of fish)		Commercial	
Harvest (number of fish)	3,054,440	Sport trips	34,542	Personal income	20,157,565
Ex-vessel harvest value	11,687,271	Expenditures	6,112,338	Jobs	399
Tribal		Jefferson County		Sport	
Harvest (number of fish)	259,824	Catch (number of fish)		Personal income	83,849,526
Ex-vessel harvest value	1,581,515	Sport trips	34,007	Jobs	1,419
Total		Expenditures	6,017,614	Total	
Harvest (number of fish)	3,314,264	Strait of Juan de Fuca Region Total		Personal income	104,007,091
Ex-vessel harvest value	13,268,786	Catch (number of fish)		Jobs	1,818
South Puget Sound		Sport trips	68,549	South Puget Sound	
King County		Expenditures	12,129,952	King County	
Non-Tribal		Total All PS regions		Commercial	
Harvest (number of fish)	564,587	Catch (number of fish)	172,760	Personal income	6,140,307
Ex-vessel harvest value	2,531,859	Sport trips	1,502,267	Jobs	76
Tribal		Expenditures	265,830,434	Sport	
Harvest (number of fish)	169,829	Washington Coast		Personal income	57,896,816
Ex-vessel harvest value	1,510,019	Catch (number of fish)		Jobs	721
Total		Sport trips	-	Total	
Harvest (number of fish)	734,416	Expenditures	-	Personal income	64,037,123
Ex-vessel harvest value	4,041,878	Oregon Coast		Jobs	797
Pierce County		Catch (number of fish)		Pierce County	
Non-Tribal		Sport trips	-	Commercial	
Harvest (number of fish)	36,170	Expenditures	-	Personal income	762,317
Ex-vessel harvest value	122,941	Total All Regions		Jobs	13
Tribal		Catch (number of fish)	172,760	Sport	
Harvest (number of fish)	36,597	Sport trips	1,502,267	Personal income	30,254,085
Ex-vessel harvest value	378,857	Expenditures	265,830,434	Jobs	522
Total				Total	
Harvest (number of fish)	72,767			Personal income	31,016,402
Ex-vessel harvest value	501,797			Jobs	535
Thurston County				Thurston County	
Non-Tribal				Commercial	
Harvest (number of fish)	6,528			Personal income	824,619
Ex-vessel harvest value	49,816			Jobs	15
Tribal				Sport	
Harvest (number of fish)	34,936			Personal income	8,458,113
Ex-vessel harvest value	492,992			Jobs	156
Total				Total	
Harvest (number of fish)	41,464			Personal income	9,282,732
Ex-vessel harvest value	542,808			Jobs	171
Mason County				Mason County	

COMMERCIAL		RECREATIONAL		REGIONAL ECON IMPACTS	
Existing Conditions (2010-2014)		**Existing Conditions (2010-2014)**		**Existing Conditions (2010-2014)**	
Region	Number	Region	Number	Region	Number
Non-Tribal				Commercial	
Harvest (number of fish)	92,693			Personal income	2,970,542
Ex-vessel harvest value	892,168			Jobs	70
Tribal				Sport	
Harvest (number of fish)	88,588			Personal income	5,095,478
Ex-vessel harvest value	1,063,202			Jobs	119
Total				Total	
Harvest (number of fish)	181,281			Personal income	8,066,020
Ex-vessel harvest value	1,955,370			Jobs	189
Kitsap County				Kitsap County	
Non-Tribal				Commercial	
Harvest (number of fish)	640			Personal income	112,498
Ex-vessel harvest value	6,224			Jobs	2
Tribal				Sport	
Harvest (number of fish)	2,301			Personal income	18,518,194
Ex-vessel harvest value	67,829			Jobs	326
Total				Total	
Harvest (number of fish)	2,941			Personal income	18,630,692
Ex-vessel harvest value	74,052			Jobs	328
South Puget Sound Region Total				South Puget Sound Region Total	
Non-Tribal				Commercial	
Harvest (number of fish)	700,618			Personal income	10,810,283
Ex-vessel harvest value	3,603,008			Jobs	176
Tribal				Sport	
Harvest (number of fish)	332,251			Personal income	120,222,686
Ex-vessel harvest value	3,512,898			Jobs	1,844
Total				Total	
Harvest (number of fish)	1,032,869			Personal income	131,032,969
Ex-vessel harvest value	7,115,905			Jobs	2,020
Strait of Juan de Fuca				Strait of Juan de Fuca Region	
Clallam County				Clallam County	
Non-Tribal				Commercial	
Harvest (number of fish)	6,777			Personal income	692,163
Ex-vessel harvest value	63,435			Jobs	16
Tribal				Sport	
Harvest (number of fish)	40,211			Personal income	6,045,562
Ex-vessel harvest value	392,184			Jobs	142
Total				Total	
Harvest (number of fish)	46,988			Personal income	6,737,724
Ex-vessel harvest value	455,618			Jobs	159
Jefferson County				Jefferson County	
Non-Tribal				Commercial	
Harvest (number of fish)	18,080			Personal income	273,074
Ex-vessel harvest value	148,409			Jobs	7
Tribal				Sport	
Harvest (number of fish)	2,750			Personal income	4,958,168
Ex-vessel harvest value	31,343			Jobs	131
Total				Total	
Harvest (number of fish)	20,831			Personal income	5,231,242
Ex-vessel harvest value	179,752			Jobs	138

COMMERCIAL		RECREATIONAL		REGIONAL ECON IMPACTS	
Existing Conditions (2010-2014)		**Existing Conditions (2010-2014)**		**Existing Conditions (2010-2014)**	
Region	Number	Region	Number	Region	Number
Strait of Juan de Fuca Region Total				Strait of Juan de Fuca Region Total	
Non-Tribal				Commercial	
Harvest (number of fish)	24,857			Personal income	965,237
Ex-vessel harvest value	211,843			Jobs	23
Tribal				Sport	
Harvest (number of fish)	42,962			Personal income	11,003,729
Ex-vessel harvest value	423,527			Jobs	273
Total				Total	
Harvest (number of fish)	67,819			Personal income	11,968,966
Ex-vessel harvest value	635,370			Jobs	296
Total All PS regions				Total All PS regions	
Non-Tribal				Commercial	
Harvest (number of fish)	3,779,914			Personal income	31,933,084
Ex-vessel harvest value	15,502,122			Jobs	599
Tribal				Sport	
Harvest (number of fish)	635,037			Personal income	215,075,942
Ex-vessel harvest value	5,517,940			Jobs	3,536
Total				Hatchery Operations	
Harvest (number of fish)	4,414,951			Personal income	11,113,108
Ex-vessel harvest value	21,020,062			Jobs	210
Washington Coast				Total	
Non-Tribal				Personal income	258,122,134
Harvest (number of fish)	-			Jobs	4,345
Ex-vessel harvest value	-			Washington Coast	
Tribal				Commercial	
Harvest (number of fish)	-			Personal income	-
Ex-vessel harvest value	-			Jobs	-
Total				Sport	
Harvest (number of fish)	-			Personal income	-
Ex-vessel harvest value	-			Jobs	-
Oregon Coast				Total	
Non-Tribal				Personal income	-
Harvest (number of fish)	-			Jobs	-
Ex-vessel harvest value	-			Oregon Coast	
Tribal				Commercial	
Harvest (number of fish)	-			Personal income	-
Ex-vessel harvest value	-			Jobs	-
Total				Sport	
Harvest (number of fish)	-			Personal income	-
Ex-vessel harvest value	-			Jobs	-
Total All Regions				Total	
Non-Tribal				Personal income	-
Harvest (number of fish)	3,779,914			Jobs	-
Ex-vessel harvest value	15,502,122			Total All Regions	
Tribal				Commercial	
Harvest (number of fish)	635,037			Personal income	31,933,084
Ex-vessel harvest value	5,517,940			Jobs	599
Total				Sport	
Harvest (number of fish)	4,414,951			Personal income	215,075,942
Ex-vessel harvest value	21,020,062			Jobs	3,536
				Hatchery Operations	

COMMERCIAL		RECREATIONAL		REGIONAL ECON IMPACTS	
Existing Conditions (2010-2014)		Existing Conditions (2010-2014)		Existing Conditions (2010-2014)	
Region	Number	Region	Number	Region	Number
				Personal income	11,113,108
				Jobs	210
				Total	
				Personal income	258,122,134
				Jobs	4,345

Source: catch data from NMFS catch database; economic factors from Appendix B, Socioeconomics.

Key Assumptions

The following key assumptions were incorporated into the economic assessment of commercial and recreational salmon fisheries associated with production of salmon and steelhead at Duwamish-Green River Basin hatcheries.

- The allocation of freshwater tribal catch among ports was based on the assumption that the catch was assigned to the closest port area to a usual and accustomed fishing area
- Average fish weights and prices in 2015 were assumed in the analysis.
- Labor requirements per harvested fish for tribal and non-tribal commercial fishing operations were assumed not to vary across the three regions.
- Average personal income, as a percentage of gross income, was assumed not to vary for tribal and non-tribal commercial fishing operations across the three regions.
- A single direct income multiplier was used in all subregions to estimate personal income effects, which assumes that, on average, direct income per dollar of gross salmon revenue would not vary across the three subregions.

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