FINAL~~DRAFT~~ ENVIRONMENTAL IMPACT STATEMENT

Draft 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

Prepared by the
National Marine Fisheries Service, West Coast Region

March 2016~~November 2015~~

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, Washington 98115

March 3, 2016

Dear Reviewer:

In accordance with provisions of the National Environmental Policy Act (NEPA), we enclose for your review the *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.*

This final Environmental Impact Statement (EIS) assesses environmental impacts associated with NMFS' review and approval of five hatchery and genetic management plans (HGMPs) submitted jointly by the fishery co-managers for hatchery programs 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.

Additional copies of the final EIS may be obtained from the Responsible Program Official identified below. The document is also accessible electronically through the NMFS West Coast Region's website at http://www.westcoast.fisheries.noaa.gov/hatcheries/salmon_and_steelhead_hatcheries.html.

NOAA's NEPA implementing procedures do not require responses to comments received on the final EIS (NOAA Administrative Order 216-6). However, comments received by **April 11, 2016,** will be reviewed and considered for their impact on issuance of a record of decision. Please send comments to the responsible official identified below. The record of decision will be made publicly available following final Agency action on or after **April 11, 2016**.

Responsible Program Official:

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Sincerely,

William Stelle

William W. Stelle, Jr.
Regional Administrator

Enclosure

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Cover Sheet
March 2016~~November 2015~~

Title of Environmental Review:	Final~~Draft~~ 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
Responsible Agency and Official:	William Stelle, Jr., Regional Administrator National Marine Fisheries Service, West Coast Region 7600 Sand Point Way NE, Building 1 Seattle, WA 98115
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 Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins in Puget Sound, Washington State
Proposed Action:	NMFS would review and evaluate five hatchery programs submitted by the fishery co-managers for the augmentation of steelhead fisheries. The operator is the Washington Department of Fish and Wildlife. NMFS would evaluate and make Endangered Species Act (ESA) take determinations under the ESA Limit 6 of 4(d) rules for listed Puget Sound Chinook salmon and steelhead.
Abstract:	The Washington Department of Fish and Wildlife and the Puget Sound treaty tribes jointly submitted five hatchery and genetic management plans for steelhead hatchery programs in Puget Sound, as resource management plans. 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's determination of whether the plans achieve the conservation standards of the ESA, as set forth in Limit 6 of 4(d) rules 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 five Puget Sound steelhead hatchery programs under the full range of alternatives.

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Summary

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

Introduction

The National Marine Fisheries Service (NMFS) has prepared this environmental impact statement (EIS) in compliance with the National Environmental Policy Act (NEPA) after the co-managers submitted to NMFS five hatchery and genetic management plans (HGMPs) for early winter steelhead in Puget Sound for review and approval under the ESA. The HGMPs involve early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Snohomish, and Snoqualmie River basins.

NMFS began this EIS process in 2015 when it requested scoping input from the public to develop alternatives to evaluate in an environmental assessment (EA) for three of the early winter steelhead hatchery programs. After considering public comments on the draft EA, NMFS decided to prepare an EIS that would evaluate all five of the early winter steelhead hatchery programs in Puget Sound, including the three that were reviewed in the draft EA. Therefore, in November 2015, NMFS published a draft EIS for public review and comment. In that draft, NMFS evaluated the resource effects of four alternatives (one no-action alternative and three action alternatives). NMFS received about 2,000 comments from the public during the comment period.

NMFS has incorporated public comments and suggestions, as well as more recent information on the affected resources, into this final EIS. NMFS has identified and evaluated Alternative 5, the preferred alternative, in this final EIS.

In addition to identifying the preferred alternative, several other updates and clarifications have been made to the EIS (for a summary of major changes to the draft EIS that are reflected in this final EIS, see the last subsection of this Summary). Some of the major changes include:

- Clarifications regarding HGMP submissions, and the relationships between NEPA and ESA processes
- Updated information describing existing conditions such as water quantity, genetic risks, summer-run steelhead hatchery programs, effects on recreational and tribal fishing, and more
- Additional information on alternatives

Background

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 potential risks to natural-origin 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) and the Puget Sound treaty tribes (hereafter referred to as the co-managers) have jointly submitted to the National Marine Fisheries Service (NMFS) hatchery and genetic management plans (HGMPs) for five hatchery programs that would produce early returning ("early") winter steelhead 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 resource management plans (RMPs) under Limit 6 of the 4(d) Rule under the 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	ESU/DPS	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's determination of whether the HGMPs submitted as RMPs achieve the conservation standards of the ESA, as set forth in Limit 6 under the salmon and steelhead 4(d) Rules, 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 RMPs meet ESA requirements—those determinations are made under the specific criteria of the ESA and the section 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 five early winter steelhead hatchery programs under the full range of alternatives.

What are 4(d) rules?

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, but some take of threatened species that does not interfere with survival and recovery may be allowed.

The salmon and steelhead 4(d) rules apply take prohibitions to all actions except those within the 13 limits to the rules. 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.

Proposed Action

Under the Proposed Action, NMFS would make a determination that the HGMPs submitted as RMPs, meet the requirements of Limit 6 under the 4(d) Rule of the ESA. 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 steelhead hatchery programs would (1) collect broodstock; (2) spawn, incubate, and rear fish; (3) release fish; or (4) remove surplus hatchery-origin adult steelhead that return to hatchery facilities; and (5) conduct monitoring and evaluation activities. The project area includes the Dungeness, Nooksack, Stillaguamish, Snohomish/Skykomish, and Snoqualmie River basins. Portions of 5 counties in Washington State are included. These five hatchery programs operate using eight hatchery facilities, and would produce 620,000 juvenile steelhead per year.

Purpose and Need

NMFS's purpose 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's need for the Proposed Action is to:

- Respond to the co-managers' request for an exemption from take prohibitions of section 9 of the ESA for their hatchery programs triggered by submission of HGMPs as RMPs under Limit 6 of the 4(d) Rule.

- Provide, as appropriate, tribal and non-tribal fishing opportunities as described under the state and tribal co-managers' Puget Sound Salmon Management Plan implemented under *United States v. Washington.*

The co-managers' purpose in developing and submitting HGMPs and submitting them as RMPs under Limit 6 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 ESA's 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' need for the Proposed Action is to continue to maintain and operate 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) Rules for any of the five HGMPs, and WDFW would discontinue its early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins (Table S-2). This No-action Alternative represents NMFS's best estimate of what would happen in the absence of the Proposed Action – a determination that the co-managers' submitted HGMPs meet requirements of the 4(d) Rule.

Table S-2. Annual hatchery releases of juvenile steelhead under the alternatives by river basin.

River Basin	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Native Broodstock)	Alternative 5 (Preferred Alternative)
Dungeness	0	10,000	5,000	10,000	10,000
Nooksack	0	150,000	75,000	150,000	150,000
Stillaguamish	0	130,000	65,000	130,000	130,000
Skykomish	0	256,000	128,000	256,000	167,600
Snoqualmie	0	74,000	37,000	74,000	74,000
Total	**0**	**620,000**	**310,000**	**620,000**	**531,600**

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 early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be implemented as described in the five submitted HGMPs (Table S-2), and up to 620,000 steelhead yearlings would be released. The hatchery programs would utilize existing hatchery capacity for operations, and would be adaptively managed over time to incorporate best management practices as new information is available.

Alternative 3 (Reduced Production)

Under this alternative, WDFW would reduce the number of fish released from each of the five proposed hatchery programs by 50 percent (to 310,000 steelhead yearlings) because it represents a mid-point between the Proposed Action (Alternative 2) and the No-action Alternative (Alternative 1) (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 RMPs meet the requirements of the 4(d) Rule.

NMFS's 4(d) regulations do not provide NMFS with the authority to order changes of this magnitude as a condition of approval of the HGMPs submitted as RMPs. NMFS's 4(d) regulations require NMFS to make a determination that the HGMPs submitted as RMPs *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 (Native Broodstock)

Under this alternative, WDFW would change its program management to transition the programs from the current non-native Chambers Creek stock to broodstock derived from fish native to the respective watershed in the project area (Table S-2). While this could be done in multiple ways, involving different periods of time and various objectives (e.g., conservation, and later, harvest), for the purpose of this analysis NMFS assumes that use of Chambers Creek stock in the broodstock would be terminated immediately. Fish taken for broodstock would then only be those determined to be native to the given watershed. It is likely that considerable time would be needed for development and implementation of a native broodstock program after termination of an early winter steelhead program.

Broodstock collection would be contingent upon availability of natural-origin fish, ensuring first that an appropriate number of fish would be able to spawn naturally; after that critical threshold is ensured, then a proportion of additional returns would be taken into the hatchery facilities.

NMFS's 4(d) regulations do not provide NMFS with the authority to order changes of this magnitude as a condition of approval of the HGMPs submitted as RMPs. NMFS's 4(d) regulations require NMFS to make a determination that the HGMPs submitted as RMPs *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 5 (Preferred Alternative)

Following release of the draft EIS for public comment and discussions with NMFS, the co-managers submitted a revised HGMP for the Skykomish River basin that included reduced smolt release levels. Under this alternative, NMFS would make a determination that the HGMPs submitted by the co-managers, including the newly revised HGMP for the Skykomish early winter steelhead program, meet requirements of the 4(d) Rule. The early winter steelhead hatchery programs proposed in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be implemented as described in the submitted HGMPs. The total annual maximum release level of early winter steelhead into the

Skykomish River basin would be up to 167,600 yearlings. The difference in early winter steelhead release levels in the Skykomish River basin described under Alternative 2, which would be up to 256,000 yearlings, and under this alternative, was proposed to address additional data and analyses of gene flow and fitness from hatchery-origin steelhead to natural-origin winter steelhead. Under Alternative 3, up to 128,000 steelhead yearlings would be released, compared to 167,000 under Alternative 5.

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

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.

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

Alternative	NMFS Review, Evaluation, and Approval of Plans under 4(d) Rules	Number of Hatchery-origin Fish Released	Changes in Hatchery Programs	Conservation Benefit[1] to Salmon and Steelhead
Alternative 1 (No Action)	No evaluation and determination under the 4(d) rules	0	Early winter steelhead programs would be terminated.	Teminating releases would eliminate any risk to listed salmon and steelhead from early winter steelhead hatchery programs.
Alternative 2 (Proposed Action)	Evaluation and determination under the 4(d) rules	620,000	Existing production levels would continue, and conservation measures would be applied to early winter steelhead hatchery programs to reduce risks and to meet conservation requirements.	Conservation requirements for listed salmon and steelhead would be met.
Alternative 3 (Reduced Production)	Same as Alternative 2	310,000	Releases of early winter steelhead hatchery programs would be reduced 50 percent.	Conservation requirements for listed salmon and steelhead would be met, and risks from early winter steelhead production would be reduced.
Alternative 4 (Native Broodstock)	Same as Alternative 2	620,000	Use of early winter steelhead broodstock would be terminated immediately; the hatchery programs would transition to broodstock derived from fish native to the watershed.	Conservation requirements for listed salmon and steelhead would be met.
Alternative 5 (Preferred Alternative)	Same as Alternative 2	531,600	Existing production levels would continue, but the number of early winter steelhead smolts released into the Skykomish River basin would be 167,600, which is between Alternative 2 (256,000) and Alternative 3 (128,000). Conservation measures would be applied to early winter steelhead hatchery programs to reduce risks and to meet conservation requirements.	Conservation requirements for listed salmon and steelhead would be met, and risks from early winter steelhead production would be reduced.

[1] ESA determinations will not be made in this EIS. They will be made in separate processes consistent with the applicable regulations as required by the ESA.

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

Resource	Alternative 1 (No Action – termination)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Reduced Production)	Alternative 4[1] (Native Broodstock)	Alternative 5 (Preferred Alternative)
Water Quantity	Compared to existing conditions, the early winter steelhead hatchery programs would be terminated, but all of the hatchery facilities that support the programs would continue to operate to produce fish for programs that are not part of the Proposed Action.	The hatchery programs would continue to operate at existing levels, and would have negligible to moderate negative effects on water quantity, depending on the hatchery program, compared to Alternative 1.	Effects on water quantity would be the same as Alternative 2, because all of the hatchery facilities that support the programs would continue to operate to produce fish for programs that are not part of the Proposed Action.	Same as Alternative 3.	Same as Alternative 3.
Salmon and Steelhead	Because early winter steelhead hatchery production would be terminated, negative and positive effects to salmon or steelhead from the programs would be eliminated, compared to existing conditions.	The hatchery programs would continue to operate at existing levels, and would generally have negligible to low negative effects on gene flow, competition and predation, hatchery facilities, masking, incidental fishing, and disease transfer effects; and negligible positive effects from nutrient cycling, depending on the hatchery program and affected species. As under existing conditions, there would be no benefit to the viability of the listed steelhead DPS.	Same as Alternative 2, except that effects from gene flow, competition and predation, hatchery facilities, masking, incidental fishing, and disease transfer from early winter steelhead would be reduced. There would be no change in viability benefit to the listed steelhead DPS compared to existing conditions.	Same as Alternative 2 except that collection of local native broodstock could have a low negative effect on the abundance and spatial structure of the natural-origin populations (i.e., mining), and a potential positive benefit to viability of the listed steelhead DPS.	Similar to Alternative 2, except that negative and positive effects would be less than Alternative 2, but greater than Alternative 3.

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

Resource	Alternative 1 (No Action – termination)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Reduced Production)	Alternative 4[1] (Native Broodstock)	Alternative 5 (Preferred Alternative)
Other Fish Species	Because early winter steelhead hatchery production would be terminated, other fish species would be affected if they compete with, are prey of (positive effect), or prey on (negative effect) early winter hatchery-origin steelhead, compared to existing conditions.	The hatchery programs would continue to operate at existing levels, and would have low negative to negligible positive effects on other fish species if they compete with or are prey of (negative effect), or prey on fish from early winter steelhead hatchery programs (positive effect), compared to Alternative 1.	Same as Alternative 2, except that the food supply for fish species that benefit from steelhead as prey would be reduced, and risk to other fish species that compete with, are prey of, or prey on steelhead would be reduced, compared to Alternative 2.	Same as Alternative 2.	Similar to Alternative 2, except that negative and positive effects would be less than Alternative 2 but greater than Alternative 3.
Wildlife – Southern Resident killer whale	Because early winter steelhead hatchery production would be terminated, early winter steelhead prey that would have been available to Southern Resident killer whales under existing conditions would be eliminated. This reduction from existing conditions would likely result in a negligible negative effect. Southern Resident killer whales would continue to occupy their existing habitats with a similar abundance, and would continue to prey on available salmon and other steelhead, especially Chinook salmon, as under existing conditions.	The hatchery programs would continue to operate at existing levels, and would have a negligible positive effect on Southern Resident killer whales, which would continue to occupy their existing habitats with a similar abundance, and would continue to prey on salmon and steelhead, especially Chinook salmon, compared to Alternative 1.	Similar to Alternative 2, except that early winter steelhead hatchery production and adult returns would decrease, reducing the supply of steelhead available to Southern Resident killer whales as prey. Alternative 3 would have a less negligible positive effect than Alternative 2.	Same as Alternative 2.	Similar to Alternative 2, except that positive effects would be less than Alternative 2 but greater than Alternative 3.

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

Resource	Alternative 1 (No Action – termination)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Reduced Production)	Alternative 4[1] (Native Broodstock)	Alternative 5 (Preferred Alternative)
Socioeconomics	Because early winter steelhead hatchery production would be terminated, non-tribal and tribal fishing opportunities would be reduced and there would be a loss of person income and jobs, compared to existing conditions.	The hatchery programs would continue to operate at existing levels, and would have low to moderate positive socioeconomic effects from hatchery operations and fishing activities (non-tribal and tribal), compared to Alternative 1.	Same as Alternative 2, except that the socioeconomic effects from hatchery operations and fishing (non-tribal and tribal) would decrease.	Same as Alternative 2.	Similar to Alternative 2, except that positive effects would be less than Alternative 2, but greater than Alternative 3.
Environmental Justice	Because early winter steelhead hatchery production would be terminated, reduced fishing opportunities would negatively impact all communities of concern, and affected Native American tribes, compared to existing conditions.	The hatchery programs would continue to operate at existing levels, and would provide low positive effects from fishing opportunities for all communities of concern, and moderate positive effects for Native American tribes, compared to Alternative 1.	Same as Alternative 2, except that fishing opportunities for all communities of concern, and for Native American tribes, would decrease.	Same as Alternative 2.	Similar to Alternative 2, except that positive effects would be less than Alternative 2, but greater than Alternative 3.

[1] Potential differences between the no action and the action alternatives would be due to differences in hatchery production levels and program type under the action alternatives.

Summary of Major Changes Made in Response to Public Comments on the Draft EIS

Below is a summary of major changes made to the draft EIS. Changes were also made for editorial reasons or purposes of clarification, and these are not listed. The location of text modifications is denoted by chapter.

Summary:

1. Added information on the NEPA process.
2. Added Alternative 5 (Preferred Alternative) and information summarizing its effects.
3. Added information summarizing major changes that resulted from public comments on the draft EIS.

Chapter 1:

1. Added information clarifying the five early winter steelhead HGMPs that were submitted to NMFS for review under the ESA and for NEPA analysis.
2. Clarified monitoring activities under the proposed HGMPs.
3. Added information on public review and comments received on the draft EIS.
4. Added information on Secretarial Order 3206, regarding limits on tribal activity.

Chapter 2:

1. Added information clarifying changes in HGMPs submitted to NMFS for review under the ESA.
2. Added Table X showing numbers of steelhead smolts that would be released under each alternative.
3. Provided more information on Alternative 4 (Native Broodstock).
4. Added Alternative 5 (Preferred Alternative).
5. Provided additional rationale for not analyzing an increased production alternative.
6. Added the rationale for selection of the preferred alternative in the final EIS, and identified a potential environmentally preferable alternative (to be identified in the Record of Decision).

Chapter 3:

1. Added information clarifying existing conditions in the context of the Consent Decree in Wild Fish Conservancy's lawsuit against WDFW regarding operation of the hatcheries producing early winter steelhead.

2. Included information from the most recent 5-year status review for Puget Sound steelhead.
3. Added Table Y showing total numbers of salmon and steelhead analyzed in the Puget Sound Hatcheries Draft Environmental Impact Statement (2014a) and in this EIS.
4. Updated information on analysis of genetic risks.
5. Added information on hatchery-origin summer-run steelhead.
6. Added information on predation effects, including indirect predation.
7. Added information on early returning natural-origin steelhead.
8. Added information on effects of incidental fishing on early returning natural-origin steelhead and tribal fisheries.
9. Clarified harvest impacts to Puget Sound steelhead, and added text to clarify the other ESA and NEPA analyses that address those impacts.

Chapter 4:

1. Added information on effects to all resources under Alternative 5 (Preferred Alternative).
2. Updated information on the amount of water use at hatchery facilities under all alternatives.
3. Updated analyses of effects of water used under the alternatives.
4. Clarified monitoring activities under the action alternatives.
5. Updated information on analysis of genetic risks under the alternatives.
6. Added information on effects to early returning natural-origin steelhead under the alternatives.
7. Clarified that jobs at hatchery facilities that would produce early winter steelhead would not be affected under the alternatives.
8. Updated the summary of environmental consequences by resource and alternative in Table 16.

Chapter 5:

1. Added information on density-dependent effects in the marine environment.

Appendices:

1. Updated information in Appendix A to include a resubmitted HGMP.
2. Updated information in Appendix B to include new information and analysis.
3. Added a new Appendix D that summarizes information on public review of the draft EIS, general comment themes, and comment responses.

Acronyms and Abbreviations

CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	Cubic feet per second
DAO	Departmental Administrative Order
DGF	Demographic gene flow
DPS	Distinct population segment
EA	Environmental assessment
Ecology	Washington Department of Ecology
EIS	Environmental impact statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily significant unit
FONSI	Finding of No Significant Impact
FTE	Full-time equivalent
HGMP	Hatchery and genetic management plan
HSRG	Hatchery Scientific Review Group
MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service (also called NOAA Fisheries Service)
NPDES	National Pollutant Discharge Elimination System
PEHC	Proportionate effective hatchery contribution
PEPD	Pending Evaluation and Proposed Determination
pHOS	Proportion of hatchery-origin spawners
PNI	Proportionate natural influence

RM	River mile
RMP	Resource management plan
ROD	Record of Decision
Services	USFWS and NMFS
TRT	Technical Recovery Team
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

Glossary of Key Terms

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 in 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.

Adipose fin: A small fleshy fin with no rays, located between the dorsal and caudal fins of salmon and steelhead. The adipose fin is often "clipped" on hatchery-origin fish so they can be differentiated from natural-origin fish.

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 freshwater 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.

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

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 the 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 United States Endangered Species Act (ESA), which refers to use and 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-U.S. Fish and Wildlife Service (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.

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

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 in 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.

First Nation: A term referring to the aboriginal people located in what is now Canada.

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

Fishway: Any structure or modification to a natural or artificial structure for the purpose of providing or enhancing fish passage.

Fitness: As used in this EIS, the propensity of a group of fish (e.g., populations) 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 one year old and have absorbed their egg sac.

Gene flow: See 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.

Hatchery and genetic management plan (HGMP): Technical documents that describe the composition and operation of individual hatchery programs. Under Limit 5 of the 4(d) rule, NMFS uses information in HGMPs to evaluate impacts on salmon and steelhead listed under the ESA.

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 2005.

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.

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 6: Under section 4(d) of the ESA (see **Section 4(d) Rule**), a limit on “take” prohibitions that applies 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 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 *U.S. vs Washington* ruling, that assists member tribes in their role as natural resources co-managers.

Out-migration: 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.

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 will take place. See also **Proposed Action**.

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 percent 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) rules for five early winter steelhead hatchery and genetic management plans (and hatchery releases) submitted as resource management plans by the co-managers.

Puget Sound treaty tribes: Indian tribes in the project area with treaty fishing rights pursuant to *United States v. Washington*. The tribes are the Jamestown S'Klallam, Lower Elwha Klallam, Lummi, Makah, Muckleshoot, Nisqually, Nooksack, Port Gamble S'Klallam, Skokomish, Suquamish, Puyallup, Sauk-Suiattle, Squaxin Island, Stillaguamish, Swinomish, Tulalip, and Upper Skagit Tribes.

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 early winter steelhead hatchery programs in Puget Sound.

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 their home rivers.

Run size: The number of adult salmon or steelhead (i.e., harvest plus escapement) returning to their natal areas. See also **Total Return**.

Salish Sea: The network of coastal waterways located between the southwestern tip of British Columbia and the northwestern tip of the state of Washington.

Salmonid: A fish of the taxonomic family Salmonidae, which includes salmon, steelhead, and trout.

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 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.

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 their natal streams, 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.

Subsistence fisheries: Harvest by Puget Sound treat tribes to meet the nutritional needs of tribal members.

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.

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.

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 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 intake screen: A screen used to prevent entrainment of salmonids into a water diversion or intake. See also **Diversion screen**.

Watershed: An area of land 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.

Yearling: Juvenile salmon or steelhead that has reared at least 1 year in the 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

NOAA's National Marine Fisheries Service (NMFS) is the lead agency responsible for administering the 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 described in hatchery and genetic management plans (HGMPs) (Box 1-1), NMFS declared under Limit 5 and Limit 6 of the 4(d) Rule that section 9 take prohibitions would not apply to activities carried out under those HGMPs when NMFS determines that the HGMPs meet the requirements of Limit 5 and, where applicable, Limit 6.

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 Dungeness Hatchery facilities support steelhead, spring Chinook salmon, coho salmon, and pink salmon programs described in four HGMPs (Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities).

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? (continued)

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. They are jointly prepared by the Washington Department of Fish and Wildlife and Puget Sound treaty tribes. 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) and Jamestown S'Klallam Tribe, Lummi Nation, Nooksack Tribe, Stillaguamish Tribe, and Tulalip Tribes as co-managers of the fisheries resource under *United States v. Washington* (1974) (hereafter referred to as "the co-managers") (Box 1-2), have provided NMFS with five HGMPs describing five hatchery programs for early returning (hereafter referred to as "early") winter steelhead and associated monitoring and evaluation actions in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins that affect ESA-listed Puget Sound Chinook salmon, Hood Canal summer chum salmon, and Puget Sound steelhead (Table 1) (Scott and Gobin 2014). An HGMP for a Soos Creek early winter steelhead program in the Duwamish/Green River basin had been submitted by the co-managers to NMFS for review and approval in 2014 (Scott 2014) but was subsequently withdrawn from consideration by the co-managers (K. Cunningham, WDFW, email sent to Isabel Tinoco, Muckleshoot Indian Tribe, regarding Soos Creek early winter steelhead; and I. Tinoco, Muckleshoot Indian Tribe, email sent to Steve Leider, NMFS, July 8, 2015, regarding Soos Creek early winter steelhead). Thus, the withdrawn HGMP is not included in the Proposed Action and is not reviewed in this EIS. In addition, following release of the draft EIS for public comment and discussions with NMFS, the co-managers submitted a revised HGMP for the Skykomish River basin that included reduced smolt release levels (Unsworth 2016; WDFW 2016). The revised Skykomish River basin HGMP is reviewed in this EIS as a component of Alternative 5.

The HGMPs provide the frameworks through which the Washington State and Tribal jurisdictions can jointly and adaptively manage hatchery operations, monitoring, and evaluation activities, while meeting requirements specified 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 of 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 five joint HGMPs, submitted for consideration under Limit 6, to be a Resource Management Plan (RMP). For more information on the 4(d) Rule, see Subsection 1.5.3, NMFS's Determination as to Compliance with the 4(d) Rule.

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 RMPs reviewed in this 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 hatchery programs for five early winter steelhead hatchery programs (Dungeness River, Nooksack River, Stillaguamish River, Skykomish River, and Snoqualmie River).

Hatchery Program	Location	Facilities	Operator	HGMP Last Updated
Dungeness River Early Winter Steelhead Hatchery Program	Dungeness River Basin	Dungeness River Hatchery Hurd Creek Hatchery	WDFW	July 26, 2014
Kendall Creek Winter Steelhead Hatchery Program	Nooksack River Basin	Kendall Creek Hatchery McKinnon Pond	WDFW	July 26, 2014
Whitehorse Ponds Winter Steelhead Hatchery Program	Stillaguamish River Basin	Whitehorse Ponds Hatchery	WDFW	July 26, 2014
Snohomish/Skykomish Winter Steelhead Hatchery Program	Skykomish River Basin	Wallace River Hatchery Reiter Ponds	WDFW	February 16, 2016 ~~November 25, 2014~~
Tokul Creek Winter Steelhead Hatchery Program	Snoqualmie River Basin	Tokul Creek Hatchery	WDFW	November 25, 2014

1.1.3 Related National Environmental Policy Act Reviews

NMFS conducted two previous NEPA analyses relevant to this 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), and, a draft environmental assessment (EA) for three early winter steelhead programs in the Dungeness, Nooksack, and Stillaguamish River basins (i.e., Draft Environmental Assessment to Analyze the Impacts of NOAA's National Marine Fisheries Service Proposed 4(d) Determination Under Limit 4 for Three Early Winter Steelhead Hatchery Programs in the Dungeness, Nooksack, and Stillaguamish River Basins – herein referred to as the EWS Hatcheries DEA [NMFS 2015a]) (80 Fed. Reg. 15985, March 26, 2015). As discussed in the Federal Register Notice terminating review of two RMPs and appended HGMPs for hatchery programs in Puget Sound basin, NMFS determined that, following the public comment period on the PS Hatcheries DEIS (NMFS 2014a), NEPA analyses organized around smaller numbers of HGMPs would allow for a 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 are not connected; they have different operators (e.g., state and tribal), do not rely on each other for their operation or justification, and recently either have 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 hatchery programs within the Puget Sound basin are addressed in this EIS in Chapter 5, Cumulative Effects.

Public comments on the EWS Hatcheries DEA (NMFS 2015a) lead NMFS to conclude that preparation of this EIS was warranted to analyze the same three early winter steelhead hatchery programs. Furthermore, in addition to the three hatchery programs analyzed in the EWS Hatcheries DEA (NMFS 2015a), this EIS includes HGMPs describing early winter steelhead hatchery programs in the Skykomish and Snoqualmie River basins. The five HGMPs were grouped into this EIS review because all five hatchery programs pertain to early winter steelhead 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) and 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). Other information incorporated by reference from the PS Hatcheries DEIS (NMFS 2014a) is summarized within various sections of this EIS.

1.2 Description of the Proposed Action

Under the Proposed Action, NMFS would make a determination that the HGMPs submitted as RMPs meet the requirements of Limit 6 of the 4(d) Rule. Activities included in the HGMPs are as follows:

- Broodstock collection through operation of weirs, fish traps, and collection ponds (Table 2)
- Transport of broodstock from Dungeness River Hatchery to Hurd Creek Hatchery
- Holding, identification, and spawning of adult fish at Dungeness River, Hurd Creek, Kendall Creek, Whitehorse Ponds, and Wallace River Hatcheries, Reiter Ponds, and Tokul Creek Hatchery (Table 2)

- Egg incubation at Dungeness River, Hurd Creek, Kendall Creek, Whitehorse Ponds, Wallace River, and Tokul Creek Hatcheries (Table 2)
- Fish rearing at Dungeness River, Hurd Creek, Kendall Creek, Whitehorse Ponds, Wallace River, and Tokul Creek Hatcheries, and McKinnon Pond and Reiter Ponds (Table 2)
- Clipping the adipose fin of 100 percent of the hatchery-origin juveniles prior to release
- Release of up to 10,000 steelhead yearlings into the Dungeness River basin, 150,000 steelhead yearlings into the Nooksack River basin, 130,000 steelhead yearlings into the Stillaguamish River basin, 256, 000 steelhead yearlings into the Skykomish River basin, and 74,000 steelhead into the Snoqualmie River basin, for a total of 620,000 fish
- Removal of adult hatchery-origin steelhead returning to the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins at weirs, fish traps, and other collection facilities
- Monitoring and evaluation activities to assess the performance of the programs in meeting conservation, harvest augmentation, and listed fish risk minimization objectives (Table 2)

Table 2. Activities, hatchery facilities, and locations associated with five early winter steelhead programs in Puget Sound.

Activity	Facility	Location	Does Facility Exist under Baseline Conditions?	Is Facility Operated under Baseline Conditions?
Broodstock collection	Dungeness River Hatchery	RM 10.5 on the Dungeness River	Yes	Yes
	Kendall Creek Hatchery	Located at the mouth of Kendall Creek (WRIA 01.0406), tributary to the NF Nooksack River (WRIA 01.0120) at RM 46	Yes	Yes
	Whitehorse Ponds Hatchery	Located at RM 1.5 of Whitehorse Springs Creek (WRIA 05.0254A), tributary to the NF Stillaguamish River (WRIA 05.0135) at RM 28	Yes	Yes
	Wallace River Hatchery	Wallace River (WRIA 07.0940), RM 4 at the confluence with May Creek (WRIA 07.0943); enters Skykomish River (WRIA 07.0012) at RM 36, which continues as Snohomish River at RM 20.51	Yes	Yes

Table 2. Activities, hatchery facilities, and locations associated with five early winter steelhead programs in Puget Sound. (continued)

Activity	Facility	Location	Does Facility Exist under Baseline Conditions?	Is Facility Operated under Baseline Conditions?
	Reiter Ponds	Skykomish River (WRIA 07.0012) at RM 46, which continues as Snohomish River at RM 20.51	Yes	Yes
	Tokul Creek Hatchery	Located on Tokul Creek (WRIA 07.0440) at RM 0.5; tributary to Snoqualmie River (WRIA 07.0219) at RM 39.6; tributary to the Snohomish River (WRIA 07.0001) at RM 20.5	Yes	Yes
Spawning	Dungeness River Hatchery	RM 10.5 on the Dungeness River	Yes	Yes
	Kendall Creek Hatchery	Located at the mouth of Kendall Creek (WRIA 01.0406), tributary to the North Fork Nooksack River (WRIA 01.0120) at RM 46	Yes	Yes
	Whitehorse Ponds Hatchery	Located at RM 1.5 of Whitehorse Springs Creek (WRIA 05.0254A), tributary to the North Fork Stillaguamish River (WRIA 05.0135) at RM 28	Yes	Yes
	Wallace River Hatchery	Wallace River (WRIA 07.0940), RM 4 at the confluence with May Creek (WRIA 07.0943); enters Skykomish River (WRIA 07.0012) at RM 36, which continues as Snohomish River at RM 20.51	Yes	Yes
	Reiter Ponds	Skykomish River (WRIA 07.0012) at RM 46, which continues as Snohomish River at RM 20.51	Yes	Yes
	Tokul Creek Hatchery	Located on Tokul Creek (WRIA 07.0440) at RM 0.5; tributary to Snoqualmie River (WRIA 07.0219) at RM 39.6; tributary to the Snohomish River (WRIA 07.0001) at RM 20.5	Yes	Yes

Table 2. Activities, hatchery facilities, and locations associated with five early winter steelhead programs in Puget Sound. (continued)

Activity	Facility	Location	Does Facility Exist under Baseline Conditions?	Is Facility Operated under Baseline Conditions?
Incubation	Dungeness River Hatchery	RM 10.5 on the Dungeness River	Yes	Yes
	Hurd Creek Hatchery	RM 0.2 on Hurd Creek, tributary to the Dungeness River at RM 2.7	Yes	Yes
	Kendall Creek Hatchery	Located at the mouth of Kendall Creek (WRIA 01.0406), tributary to the North Fork Nooksack River (WRIA 01.0120) at RM 46	Yes	Yes
	Whitehorse Ponds Hatchery	Located at RM 1.5 of Whitehorse Springs Creek (WRIA 05.0254A), tributary to the NF Stillaguamish River (WRIA 05.0135) at RM 28	Yes	Yes
	Wallace River Hatchery	Wallace River (WRIA 07.0940), RM 4 at the confluence with May Creek (WRIA 07.0943); enters Skykomish River (WRIA 07.0012) at RM 36, which continues as Snohomish River at RM 20.51	Yes	Yes
	Tokul Creek Hatchery	Located on Tokul Creek (WRIA 07.0440) at RM 0.5; tributary to Snoqualmie River (WRIA 07.0219) at RM 39.6; tributary to the Snohomish River (WRIA 07.0001) at RM 20.5	Yes	Yes
Rearing	Dungeness River Hatchery	RM 10.5 on the Dungeness River	Yes	Yes
	Hurd Creek Hatchery	RM 0.2 on Hurd Creek, tributary to the Dungeness River at RM 2.7	Yes	Yes
	Kendall Creek Hatchery	Located at the mouth of Kendall Creek (WRIA 01.0406), tributary to the North Fork Nooksack River (WRIA 01.0120) at RM 46	Yes	Yes

Table 2. Activities, hatchery facilities, and locations associated with five early winter steelhead programs in Puget Sound. (continued)

Activity	Facility	Location	Does Facility Exist under Baseline Conditions?	Is Facility Operated under Baseline Conditions?
	McKinnon Pond	Located just downstream from the Mosquito Lake Road Bridge on the left bank of the Middle Fork Nooksack River with water from and outlet to a creek (WRIA 01.0352, known locally as "Peat Bog Creek"), which emanates from Peat Bog, tributary to Middle Fork Nooksack River (WRIA 01.0339) at RM 4.4.	Yes	Yes
	Whitehorse Ponds Hatchery	Located at RM 1.5 of Whitehorse Springs Creek (WRIA 05.0254A), tributary to the North Fork Stillaguamish River (WRIA 05.0135) at RM 28	Yes	Yes
	Wallace River Hatchery	Wallace River (WRIA 07.0940), RM 4 at the confluence with May Creek (WRIA 07.0943); enters Skykomish River (WRIA 07.0012) at RM 36, which continues as Snohomish River at RM 20.51	Yes	Yes
	Reiter Ponds	Skykomish River (WRIA 07.0012) at RM 46, which continues as Snohomish River at RM 20.51	Yes	Yes
	Tokul Creek Hatchery	Located on Tokul Creek (WRIA 07.0440) at RM 0.5; tributary to Snoqualmie River (WRIA 07.0219) at RM 39.6; tributary to the Snohomish River (WRIA 07.0001) at RM 20.5	Yes	Yes
Juvenile Fish Release	Dungeness River Hatchery	RM 10.5 on the Dungeness River	Yes	Yes
	Kendall Creek Hatchery	Located at the mouth of Kendall Creek (WRIA 01.0406), tributary to the NF Nooksack River (WRIA 01.0120) at RM 46	Yes	Yes
	Whitehorse Ponds Hatchery	Located at RM 1.5 of Whitehorse Springs Creek (WRIA 05.0254A), tributary to the NF Stillaguamish River (WRIA 05.0135) at RM 28	Yes	Yes

Table 2. Activities, hatchery facilities, and locations associated with five early winter steelhead programs in Puget Sound. (continued)

Activity	Facility	Location	Does Facility Exist under Baseline Conditions?	Is Facility Operated under Baseline Conditions?
	Whitehorse fish in excess of release goals are released into various King and Snohomish County lakes for harvest.	Various lakes that are functionally isolated from anadromous-accessible freshwater	Yes	Yes
	Wallace River Hatchery	Wallace River (WRIA 07.0940), RM 4 at the confluence with May Creek (WRIA 07.0943); enters Skykomish River (WRIA 07.0012) at RM 36, which continues as Snohomish River at RM 20.51	Yes	Yes
	Reiter Ponds	Skykomish River (WRIA 07.0012) at RM 46, which continues as Snohomish River at RM 20.51	Yes	Yes
	Tokul Creek Hatchery	Located on Tokul Creek (WRIA 07.0440) at RM 0.5; tributary to Snoqualmie River (WRIA 07.0219) at RM 39.6; tributary to the Snohomish River (WRIA 07.0001) at RM 20.5	Yes	Yes
	Tokul Creek fish in excess of release goals are released into various King County lakes for harvest.	Various lakes that are functionally isolated from anadromous-accessible freshwater	Yes	Yes
Monitoring and evaluation	Dungeness River Hatchery	RM 10.5 on the Dungeness River	Yes	Yes
	Hurd Creek Hatchery	RM 0.2 on Hurd Creek, tributary to the Dungeness River at RM 2.7	Yes	Yes
	Kendall Creek Hatchery	Located at the mouth of Kendall Creek (WRIA 01.0406), tributary to the NF Nooksack River (WRIA 01.0120) at RM 46	Yes	Yes
	Whitehorse Ponds Hatchery	Located at RM 1.5 of Whitehorse Springs Creek (WRIA 05.0254A), tributary to the NF Stillaguamish River (WRIA 05.0135) at RM 28	Yes	Yes

Table 2. Activities, hatchery facilities, and locations associated with five early winter steelhead programs in Puget Sound. (continued)

Activity	Facility	Location	Does Facility Exist under Baseline Conditions?	Is Facility Operated under Baseline Conditions?
	Wallace River Hatchery	Wallace River (WRIA 07.0940), RM 4 at the confluence with May Creek (WRIA 07.0943); enters Skykomish River (WRIA 07.0012) at RM 36, which continues as Snohomish River at RM 20.51	Yes	Yes
	Reiter Ponds	Skykomish River (WRIA 07.0012) at RM 46, which continues as Snohomish River at RM 20.51	Yes	Yes
	Tokul Creek Hatchery	Located on Tokul Creek (WRIA 07.0440) at RM 0.5; tributary to Snoqualmie River (WRIA 07.0219) at RM 39.6; tributary to the Snohomish River (WRIA 07.0001) at RM 20.5	Yes	Yes
	Watershed areas accessible to natural salmon and steelhead migration, spawning and rearing	Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basin areas, including tributaries, extending from the river mouths through the upstream extent of anadromous fish access.	N/A	N/A

Sources: WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e, WDFW 2016.
RM: River mile, measured from the farthest downstream point on the stream in question.
WRIA: Water Resources Inventory Area, typically defining geographic areas where surface-water run-off drains into a common surface-water body, such as a lake, section of a stream, or a bay.

As described in Subsection 1.5.3, NMFS's Determination as to Compliance with the 4(d) Rule, NMFS will 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 (DNA) and gene flow (e.g., Anderson et al. 2014), and juvenile and adult fish health when the fish are in the hatchery.

1.3 Purpose of and Need for the Proposed Action

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

NMFS's purpose 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's need for the Proposed Action is to:

- Respond to the co-managers' request for an exemption from take prohibitions of section 9 of the ESA for their hatchery programs triggered by submission of HGMPs as RMPs under Limit 6 of the 4(d) Rule.
- Provide, as appropriate, tribal and non-tribal fishing opportunities as described under the state and tribal co-managers' Puget Sound Salmon Management Plan implemented under *United States v. Washington*.

The co-managers' purpose in developing and submitting HGMPs as RMPs under Limit 6 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 ESA's 4(d) Rule.

The co-managers' need for the Proposed Action is to continue to maintain and operate ~~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. However, the opinion of tribal co-managers and their immediate interest in fishing must be balanced with NMFS' responsibilities under the ESA.

This EIS will 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.

1.4 Project and Analysis Areas

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

- Dungeness River Hatchery
- Hurd Creek Hatchery
- Kendall Creek Hatchery
- McKinnon Pond
- Whitehorse Ponds
- Wallace River Hatchery
- Reiter Ponds
- Tokul Creek Hatchery

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 section 4(d) Rule

1.5.1 Preferred Alternative to be Identified in the Final EIS

Although a preferred alternative was not identified in the draft EIS; it has been identified in the final EIS in Subsection 2.2.5, Alternative 5 (Preferred Alternative). ~~The preferred alternative for all programs could be the Proposed Action, or it could be comprised of components of the alternatives evaluated in the final EIS.~~ Information from the public review process was 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 the selected alternative. The ROD will identify the environmentally preferred alternative; describe the preferred alternative and the selected alternative; and summarize the impacts expected to result from implementation of the selected alternative. As for the preferred alternative in the final EIS, the selected alternative in the ROD could be the preferred alternative or could be comprised 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's 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 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 ESA 4(d) Rule Limit 5 and Limit 6 criteria have been met will be documented in NMFS's ESA decision documents at the end of the ESA evaluation process. 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's Determination as to Compliance with the 4(d) Rule

ESA section 7(a)(2) 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's actions under section 4(d) are Federal actions, and NMFS must comply with section 7(a)(2). NMFS's consultations under section 7 on those actions 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 (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 will 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 that 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.

1.6.1 Scoping Process

This EIS involved activities that included both internal and public scoping that are described in the following paragraphs.

1.6.2 Internal Scoping

NMFS initially conducted internal project scoping on early winter steelhead hatchery programs in 2014, as part of the process of developing the draft EA for three early winter steelhead hatchery programs, and convened later, internal-only, meetings for the process of developing this EIS. Internal scoping for this EIS was informed by public comments on previous NEPA analyses including the PS Hatcheries DEIS (NMFS 2014a) and the EWS Hatcheries DEA (NMFS 2015a).

A review of available NEPA analyses of salmon and steelhead hatchery programs in Puget Sound watersheds including the PS Hatcheries DEIS (NMFS 2014a) and EWS Hatcheries DEA (NMFS 2015a), the 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), and Draft 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 Dungeness Hatcheries DEA (NMFS 2015b) (80 Fed. Reg. 9260, February 20, 2015), found that the proposed actions had negligible effects on some resources or parts of resources. These resources were wildlife, water quality, and human health. Analyses of these resources in the above documents are incorporated by reference; further analyses were not proposed to be reviewed in Chapter 3, Affected Environment, and Chapter 4, Environmental Consequences, in this EIS.

1.6.3 Notices of Public Scoping

Public scoping for this EIS commenced with publication of a Notice of Intent in the Federal Register on July 14, 2015 (80 Fed. Reg. 41011, July 14, 2015). That notice started a 30-day public comment period (July 14, 2015, to August 13, 2015) 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.

During 2015, NMFS held two public scoping workshops in the project area, in Mount Vernon (on July 20), and in Lynnwood (on July 21), Washington. Presentations were made by NMFS personnel, and a question-and-answer session followed. At these workshops, NMFS provided clarifying information and requested that public comments be submitted on issues and alternatives associated with the project. Notifications about the workshops, the public scoping process, and the EIS schedule were distributed in a press release and in emails to a list of over 2,000 addresses that had been compiled from people that commented on the EWS Hatcheries DEA (NMFS 2015a) and PS Hatcheries DEIS (NMFS 2014a). Electronic and other notifications were sent to agencies, private individuals, businesses, and non-governmental organizations, which contained a link to the website for this EIS and the address to the EIS electronic mailbox. Invitations to attend the public workshops were also advertised through a NMFS press release and on applicable organization and agency websites.

1.6.4 Written Comments Received during the Public Scoping Process

Written comments received on this EIS during the public scoping process included:

- 1 from a governmental agency
- 1 from a tribal organization
- 5 from non-governmental organizations
- 639 from individual citizens

1.6.5 Issues Identified During Scoping

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

- Modify hatchery programs to help conserve species listed under the ESA.
- Modify hatchery programs to provide more fishing opportunities for steelhead.

Comments from public scoping were also received on resources to be analyzed, the importance of habitat to steelhead, and new information. Scoping identified water quantity, salmon and steelhead, Southern Resident killer whales, socioeconomics, and environmental justice as the resources to be analyzed, along with cumulative effects. Scoping comments emphasized the importance of habitat to natural-origin steelhead, life history and adult return-timing considerations, and identified recently available information (e.g., steelhead genetic data from WDFW, and Salish Sea juvenile steelhead survival studies) to be considered in the EIS.

1.6.6 ~~Future~~ Public Review and Comment

Under NEPA, the draft EIS was 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 (80 Fed. Reg.70206, November 13, 2015). NMFS received nearly 2,100 comment submissions on the draft EIS, including:

- 3 from governmental agencies
- 4 from tribal organizations
- 4 from fish conservation non-governmental organizations
- 5 fishing organizations
- 103 from individual citizens, plus nearly 2,000 form-email or form-letter submissions

Following the public review period, responses to substantive public comments were prepared and included in the final EIS ~~(Table 3)~~. Responses ~~will~~ identify any changes to the EIS resulting from public comments, as warranted. Appendix D, Comment Analysis Summary, summarizes public comments received on the draft EIS, identifies global comments, and provides responses to those comments. Changes made to the draft EIS are shown as red text for new additions and as strikethrough text for deleted information. Following a 30-day public review period for the final EIS, the ROD (Subsection 1.5.2, Record of Decision) will be signed and made publicly available.

Under the ESA 4(d) Rule Limit 6, NMFS will prepare Pending Evaluation and Proposed Determination (PEPD) documents for the proposed RMPs (Table 3). PEPD documents for early winter steelhead hatchery programs reviewed in this EIS were released for public review and comment on March 26, 2015 (80 Fed. Reg. 15985, March 26, 2015), and February 23, 2016 (81 Fed. Reg. 8941, February 23, 2016).

To the extent that the co-managers propose substantive changes to the HGMPs reviewed in this EIS in the future in response to new information ~~or proposed actions~~ (including potential increases in hatchery production), additional NEPA and ESA compliance may be warranted. The nature and extent of changes to plans or new information will determine the type of additional NEPA and ESA compliance that may be needed. Subsequent public review opportunities may be warranted as part of these additional NEPA and ESA reviews.

Table 3. NMFS documents and decisions required under the ESA and NEPA regarding early winter 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/Review**	**Decision Document**
ESA				
NMFS 4(d)		Pending Evaluation and Determination (30-day comment period)		Evaluation and Recommendation Determination[1]
NMFS BiOp[2]				Signed BiOp
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.

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 Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. They are summarized below to provide additional context for the hatchery programs and their proposed HGMPs (see Box 1-1).

1.7.1 Clean Water Act

The Clean Water Act (33 USC 1251, 1977, as amended in 1987), administered by the U.S. Environmental Protection Agency and state water quality agencies, is the principal Federal legislation directed at protecting water quality. 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 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) 173. Hatchery operations are required to comply with the Clean Water Act.

1.7.2 Bald Eagle and Golden Eagle Protection Act

The Bald Eagle 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 U.S. Fish and Wildlife Service, 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, feeding, or sheltering behavior.” Changes in hatchery production have the potential to affect eagle productivity through changes in its salmon and steelhead prey sources.

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. Changes in fish production can indirectly affect marine mammals by altering the number of available salmon and steelhead prey sources.

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. Changes in hatchery production have the potential to affect the extent of harvest available for minority and low-income populations.

1.7.5 Treaties of Point Elliot, 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 bearing upon the actions evaluated in this EIS is the Treaty of Medicine Creek (signed in 1854), followed by two treaties signed in 1855—the Point Elliot 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 Lummi Nation, Nooksack Tribe, Stillaguamish Tribe, and Tulalip Tribes are signatory to the Treaty of Point Elliot, the lands settlement treaty between the United States government and the Native American tribes of the North Puget Sound and Strait of Georgia regions, in the recently-formed Washington Territory. The Treaty of Point Elliot was signed on January 22, 1855, at Muckl-te-oh or Point Elliott, now Mukilteo, Washington.

The Jamestown S'Klallam Tribe is signatory to the Treaty of Point No Point, the lands settlement treaty between the United States government and the Native American tribes of the Strait of Juan de Fuca and Hood Canal regions (then, the S'Klallam, the Chimakum, and the Skokomish Tribes), also in the recently-formed Washington Territory. The Treaty of Point No Point was signed on January 26, 1855, at Hahdskus – the Salish dialect name for Point No Point – on the northern tip of the Kitsap Peninsula.

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 regards 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; NWIFC 2013). These fishing rights and attendant access were established by treaties that the Federal government signed with the tribes in the 1850s. 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. Under Phase II of *United States v. Washington*, the Federal District Court ensured tribes the rights to the protection of fish habitat subject to treaty catch and a right to the fish that are produced by hatcheries. 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 (*U.S. v. Washington*, 759 F.2d 1353, 1358-60 (9th Cir.), cert. denied, 474 U.S. 994 (1985)).

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, NMFS and the U.S. Fish and Wildlife Service (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 has 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."

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 (~~Cohen 2005;~~ 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).

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 steel head 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*."

1.7.10 Washington State Endangered, Threatened, and Sensitive Species Act

This EIS will consider the effects of hatchery programs and harvest actions on state endangered, threatened, and sensitive species. The State of Washington has species of concern listings (Washington Administrative Code 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 May 2015. 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 listed under the state endangered, threatened, and sensitive species list are reviewed in this EIS if actions could affect these species.

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 (WFWC 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 state hatcheries and its intent is 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

Federal recovery plans are in place for the ESA-listed Puget Sound Chinook Salmon (SSPS 2007; 72 Fed. Reg. 2493, January 19, 2007) and Hood Canal Summer Chum Salmon ESUs (Hood Canal Coordinating Council 2005; 72 Fed. Reg. 29121, May 24, 2007). Broad partnerships of Federal, state, local, and tribal governments and community organizations collaborated in the development of the two completed salmon recovery plans under Washington's Salmon Recovery Act. The comprehensive recovery plans include conservation goals and proposed habitat, hatchery, and harvest actions needed to achieve the conservation goals for each watershed within the geographic boundaries of the two listed ESUs. 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. It is projected to be completed in 2017 (http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/puget_sound/overview_puget_sound_steelhead_recovery_2.html).

1.7.13 Federal Wilderness Act

The 1964 Wilderness Act directs Federal agencies to manage wilderness so as to preserve its wilderness character. Lands classified as wilderness through the Wilderness Act may be under the jurisdiction of the U.S. Forest Service, National Park Service, U.S. Fish and Wildlife Service, or the U.S. Bureau of Land Management. With some exceptions, the Wilderness Act prohibits motorized and mechanized vehicles, timber harvest, new grazing and mining activity, or any kind of development. In 1988, Congress designated 95 percent of the Olympic National Park as wilderness under the Wilderness Act. The Olympic Wilderness Area is under the jurisdiction of the National Park Service. Some of the Dungeness River basin is within the Olympic Wilderness Area and within the Buckhorn Wilderness Area. All three forks of the Nooksack River originate in the Mount Baker Wilderness. One tributary of the Stillaguamish River – Boulder River – originates in the Boulder River Wilderness Area. Parts of the Skykomish River originate in the Henry M. Jackson Wilderness Area and the Wild Sky Wilderness Area. Parts of the Snoqualmie River originate in the Alpine Lakes Wilderness Area.

1.8 Organization of ~~this Draft~~ the Final EIS

This EIS has been prepared in accordance with NEPA (40 CFR 1500 to 1508) and with the NEPA implementing regulations adopted by NMFS (NOAA 1999). The EIS should be reviewed in conjunction with the co-managers' HGMPs for the five early winter steelhead hatchery programs (http://wdfw.wa.gov/hatcheries/hgmp/2012_puget_sound.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; however, NMFS cannot guarantee that they will remain active over time. The contents of this draft 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 four ~~three~~ action alternatives, including the Proposed Action, the Preferred Alternative, and alternatives considered but not analyzed in detail.

- **Chapter 3**. This chapter describes the existing environmental setting that would be affected by the alternatives (i.e., existing conditions). It includes subsections on water quantity, salmon and steelhead, wildlife (Southern Resident killer whales), socioeconomics, and environmental justice resources.

- **Chapter 4**. This chapter contains a description 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, and appendices.

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Chapter 2

2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

This chapter describes the ~~four~~ five 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
- A preferred alternative
- The process for developing ~~a preferred alternative and~~ an environmentally preferred alternative

2.1 Development of Alternatives

In 2015, NMFS solicited and considered public comment on the development of alternatives for this EIS (Subsection 1.6, Scoping and Relevant Issues). Two workshops were convened by NMFS and included the general public, the co-managers, and NMFS staff to discuss issues associated with possible EIS alternatives. In the Notice of Intent to develop this EIS (80 Fed. Reg. 41011, July 14, 2015), NMFS identified four alternatives for possible analysis: the Proposed Action (NMFS's approval under the ESA of implementation of the co-managers' HGMPs), no action (no hatchery releases of early winter steelhead), a 50 percent decrease in number of early winter hatchery-origin steelhead released, and a change in program type such that they would transition to use of locally-returning native steelhead as broodstock.

The public scoping process (Subsection 1.6, Scoping and Relevant Issues) identified 11 potential alternatives, including those proposed in the Notice of Intent. Of these 11 alternatives, 4 were found to represent the full range of reasonable alternatives because their components differed meaningfully from the other alternatives analyzed. The three alternatives other than the No-action Alternative met the purpose and need for the Proposed Action. Seven 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.

Following release of the draft EIS for public comment, NMFS conferred with WDFW regarding concerns about the genetic effects of the Skykomish HGMP on wild steelhead in combination with the genetic effects of Skamania summer steelhead programs in the same basin. Following that discussion, and discussions between WDFW and the Tulalip Tribes, WDFW submitted a revised Skykomish HGMP proposing lower releases of early winter steelhead smolts in combination with reductions in releases of summer steelhead. Consequently, the revised HGMP is now represented in the final EIS in Alternative 5 (Subsection 1.1.2, Hatchery Genetic Management Plan Submittal). The only difference between Alternative 2 and Alternative 5 is that Alternative 5 includes the reductions in releases of early winter steelhead smolts from the Skykomish hatchery program.

2.2 Alternatives Analyzed in Detail

~~Four~~ Five alternatives are considered 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 revised HGMPs with reduced production levels would meet requirements of the 4(d) Rule (Reduced Production); (4) NMFS would make a determination that revised HGMPs that replace Chambers Creek stock with a native broodstock meet requirements of the 4(d) Rule (Native Broodstock); and (5) NMFS would make a determination that the submitted and revised HGMPs meet requirements of the 4(d) Rule (Preferred Alternative). These alternatives are described below. Production levels under the alternatives are summarized in Table X. Relative to Alternative 2, Alternative 5 reflects a reduced number of early winter steelhead smolt releases for the Skykomish River basin. Monitoring activities would be part of all action alternatives, 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 (DNA) and gene flow (e.g., Anderson et al. 2014), and juvenile and adult fish health when the fish are in the hatchery.

Table X. Maximum annual hatchery releases of juvenile steelhead under the alternatives by river basin.

River Basin	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Native Broodstock)	Alternative 5 (Preferred Alternative)
Dungeness	0	10,000	5,000	10,000	10,000
Nooksack	0	150,000	75,000	150,000	150,000
Stillaguamish	0	130,000	65,000	130,000	130,000
Skykomish	0	256,000	128,000	256,000	167,600
Snoqualmie	0	74,000	37,000	74,000	74,000
Total	**0**	**620,000**	**310,000**	**620,000**	**531,600**

Source: HGMPs (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e; WDFW 2016).

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 five HGMPs, and WDFW would discontinue its early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. All steelhead currently being raised within the proposed hatchery programs would be killed, and no additional broodstock would be collected. This No-action Alternative represents NMFS's best estimate of what would happen in the absence of the Proposed Action – a determination that the co-managers' submitted HGMPs meet requirements of the 4(d) Rule.

2.2.2 Alternative 2 (Proposed Action) – Make a Determination that the Submitted HGMPs Meet 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 early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be implemented as described in the five submitted HGMPs (WDFW 2014a, WDFW 2014b, and WDFW 2014c, WDFW 2014d, WDFW 2014e).

Under Alternative 2, the total annual maximum release level would be 620,000 steelhead yearlings into the following river basins:

- Dungeness River basin: up to 10,000 steelhead yearlings
- Nooksack River basin: up to 150,000 steelhead yearlings
- Stillaguamish River basin: up to 130,000 steelhead yearlings
- Skykomish River basin: up to 256,000 steelhead yearlings
- Snoqualmie River basin: up to 74,000 steelhead yearlings

The hatchery programs would utilize existing hatchery capacity for operations, and would be adaptively managed over time to incorporate best management practices 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 (Reduced Production) – Make a Determination that Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

Under this alternative, WDFW would reduce the number of fish released from each of the five 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 program (310,000 steelhead yearlings) because it represents a mid-point between the Proposed Action (Alternative 2) and the No-action Alternative (Alternative 1). Note that NMFS's 4(d) regulations do not provide NMFS with the authority to order changes of this magnitude as a condition of approval of the HGMPs. NMFS's 4(d) regulations 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 under 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.

2.2.4 Alternative 4 (Native Broodstock) - Make a Determination that Revised HGMPs that Replace Chambers Creek Stock with a Native Broodstock Meet Requirements of the 4(d) Rule

Under this alternative, WDFW would change its program management to transition the programs from the current non-native Chambers Creek stock to broodstock derived from fish native to the respective watershed in the project area. While this could be done in multiple ways, involving different periods of time and various objectives (e.g., conservation, and later, harvest), for the purpose of this analysis NMFS assumes that use of Chambers Creek stock fish in the broodstock would be terminated immediately. Fish taken for broodstock would then only be those determined to be native to the given watershed. It is likely that considerable time would be needed for development and implementation of a native broodstock program after termination of an early winter steelhead program.

Broodstock collection would be contingent upon availability of natural-origin fish, ensuring first that an appropriate minimum number of fish would be able to spawn naturally; after that critical threshold is ensured, then a proportion of additional returns would be taken into the hatchery facilities. Broodstock collection would occur through fish volunteering to the hatcheries, but might also require additional collection methods, including at weirs, via hook and line, or through seining. The Proportionate Natural Influence (PNI, described in Subsection 3.2.3.1, Genetic Risks) would be 0.67 or higher, and no more than 10 percent of the naturally spawning fish in the river would be hatchery-origin spawners.

Note that NMFS's 4(d) regulations do not provide NMFS with the authority to order changes of this magnitude as a condition of approval of the HGMPs. NMFS's 4(d) regulations require NMFS to make a determination that the HGMPs *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.

2.2.5 Alternative 5 (Preferred Alternative) – Make a Determination that HGMPs Including a Revised HGMP with Reduced Production Levels in Skykomish River Basin Meet Requirements of the 4(d) Rule

Under this alternative, NMFS would make a determination that the HGMPs submitted by the co-managers, including the newly revised HGMP for the Skykomish early winter steelhead hatchery program, meet requirements of the 4(d) Rule. The early winter steelhead hatchery programs proposed in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be implemented as described in the submitted HGMPs (WDFW 2014a, WDFW 2014b, WDFW 2014c, WDFW 2014e, WDFW 2016). The total annual maximum release level of early winter steelhead into the Skykomish River basin would be up to 167,600 yearlings (WDFW 2016). The difference in early winter steelhead release levels in the Skykomish River basin described under Alternative 2 (WDFW 2014d), which would be up to 256,000 yearlings, and under this alternative (WDFW 2016), is a result of additional data and analyses of gene flow from hatchery-origin steelhead to natural-origin winter steelhead as described by Unsworth (2016) [1]. Under Alternative 3 (Reduced Production), up to 128,000 steelhead yearlings would be released (Table X).

2.3 Alternatives Considered But Not Analyzed in Detail

The following additional seven alternatives identified during scoping (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).

[1] Unsworth (2016) describes proposed releases of up to 167,600 early winter steelhead and up to 116,000 hatchery-origin summer steelhead into the Skykomish River basin.

- Hatchery programs with greater levels of hatchery production than those proposed – Under this potential alternative, WDFW would revise its HGMPs to incorporate higher production levels than those proposed. This alternative is not analyzed in detail because higher production levels would be expected to have incrementally higher environmental impacts on various resources than production levels under the Proposed Action. In addition, analysis of such an alternative would not help inform NMFS' response to the co-managers' request for an exemption from ESA take prohibitions under the 4(d) Rule, because the ESA and the 4(d) Rule are focused on limiting impacts to listed salmon and steelhead.

  ~~the purpose and need for the proposed action is for NMFS to respond to the comanagers' request for approval of the programs under Limit 6 of the 4(d) rule. Analyzing the effects of production levels higher than what the comanagers have proposed would not inform NMFS' decision, which is to approve or disapprove the proposed programs. Should the comanagers decide to propose higher production levels at some point in the future, based on new information or circumstances, additional ESA and NEPA review would likely be required. and thus would not meet the element of the purpose and need regarding compliance with the ESA. Specifically, a criterion that NMFS considers for approval of an HGMP under the 4(d) Rule is whether the HGMP "evaluates, minimizes, and accounts for the propagation program's genetic and ecological effects on natural populations . . . .". WDFW has submitted HGMPs that it believes "minimize" such effects; presumably programs with greater effects would not do so. In addition, the increased production levels would require additional capacity and development of additional hatchery facilities, which would not meet the purpose of and need for action, which includes use of existing capacity.~~

- Implement all Hatchery Scientific Review Group (HSRG) recommendations – This potential alternative would implement all recommendations made by the HSRG as an action alternative. The Washington Recreation and Conservation Office (RCO 2014) indicates that continuing and substantial progress has been made in increasing the percentage of WDFW's Puget Sound steelhead hatchery programs that meet HSRG standards (92 percent of the programs met HSRG standards in 2014). In addition, the co-managers intend to continue to implement HSRG recommendations over time using adaptive management under the Proposed Action. Thus, this potential alternative will not be analyzed in detail because it would not be substantially different from the Proposed Action.

- Confine early winter steelhead programs to pHOS less than 2 percent – Included under this potential alternative would be early winter steelhead programs having percentages of hatchery-origin spawners (pHOS) based on census methods demonstrated to be less than 2 percent (or pHOS of 5 percent maximum, regardless of effective pHOS). The pHOS metric reflects levels of hatchery-origin spawners in natural spawning areas. The co-managers, especially WDFW as a matter of policy, use pHOS to help keep genetic risks to natural-origin salmon and steelhead from hatchery programs within acceptable limits. The Proposed Action involves early winter steelhead hatchery programs that already are at or are close to those limits, and also involves rigorous genetic monitoring to detect how well the programs perform in relation to the targeted limits. Therefore, this potential alternative will not be analyzed in detail because it would not be measurably different from the Proposed Action.

- Release levels no greater than in recent years – Under this potential alternative, numbers of early winter steelhead released would be no greater than what has occurred in recent years. Release levels under the Proposed Action reflect recent steelhead program reductions and discontinuations. Thus, this potential alternative will not be analyzed in detail because it would not be measurably different from the Proposed Action.
- Production levels same as Proposed Action, but suspend releases from programs having the lowest marine survival during periods of extremely low marine survival – Under this potential alternative, early winter steelhead hatchery programs would produce hatchery fish at the same levels as under the Proposed Action; however, in years in which marine survival is extremely low, production would be suspended from programs displaying the poorest marine survival. Such practices and other best management practices would occur under the Proposed Action. Furthermore, reductions in production levels are analyzed under Alternative 3 (Reduced Production). Therefore, this potential alternative will not be analyzed in detail because it would not be measurably different from other alternatives analyzed in detail.
- Maximize recovery potential for listed species – Under this potential alternative, early winter steelhead hatchery programs would be designed to reduce risks to and increase benefits for recovery of listed species. Under the No-action Alternative, early winter steelhead hatchery programs would be terminated, effectively eliminating risks to listed species from the programs. Under Alternative 4 (Native Broodstock), early winter steelhead programs would be terminated, and new steelhead programs using local, native broodstock would be developed, consistent with the status of the listed natural-origin populations in the respective watershed. These new programs would be carefully implemented and managed under the ESA to minimize risks to the listed hatchery and natural-origin fish, and could contribute to

the viability of the local natural-origin steelhead populations. Therefore, this potential alternative will not be analyzed in detail because it would not be measurably different from other alternatives analyzed in detail.

- Develop plans for water re-use or recirculation, and plan for low flow and high temperatures – Under this potential alternative, WDFW would revise its HGMPs to address water issues by developing plans for re-use or recirculation, and contingency plans for implementation during periods when flows are especially low, and water temperatures are especially high. Under this potential alternative, these and other best management practices would continue to reduce the risk of negative impacts of the hatchery programs on natural-origin salmon and steelhead populations. NMFS would determine the revised HGMPs meet requirements of the 4(d) Rule. However, because the HGMPs have already incorporated best management practices identified by independent reviewers, and because the HGMPs allow for incorporation of additional best management practices in the future as a result of monitoring and evaluation activities and adaptive management, this alternative would not be measurably different from the Proposed Action and will not be analyzed in detail.

2.4 Selection of a Preferred Alternative and an Environmentally ~~Preferred~~ Preferable Alternative

As explained in Subsection 1.6.6, ~~Future~~ Public Review and Comment, NMFS ~~will review~~ reviewed public comments received on the draft EIS ~~and prepare a~~ to prepare the final EIS. A preferred alternative has been identified in this final EIS. The agency's preferred alternative is "the alternative which the agency believes would fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical, and other factors" (CEQ 1981). 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. Information from the public review process ~~will be~~ was used in choosing a preferred alternative. As described in Subsection 2.2.5, Preferred Alternative, NMFS has identified Alternative 5 as its preferred alternative because it would meet the components of the purpose and need for this action regarding socioeconomic and cultural benefits to recreational and tribal fishing interests and other biological and physical resources. Further, it has been preliminarily analyzed in two Proposed Evaluation and Pending Determination documents issued by NMFS (80 Fed. Reg. 15985, March 26, 2015; 81 Fed. Reg. 8941, February 23, 2016).

NMFS will also identify an environmentally ~~preferred~~ preferable alternative in the ROD. This alternative may or may not be the same as the preferred alternative. The environmentally preferable alternative is "the alternative that will promote the national environmental policy as expressed in NEPA's Section 101.

Ordinarily, this means the alternative that causes the least damage to the biological and physical environment; it also means the alternative which best protects, preserves, and enhances historic, cultural, and natural resources (CEQ 1981). Under Alternative 4 (Native Broodstock), programs would transition to native broodstock programs, which have the potential to benefit conservation and recovery of listed Puget Sound steelhead, while potentially providing harvest benefits when population sizes are large enough. Therefore, Alternative 4 may be identified as the environmentally preferable alternative in the ROD because it would further reduce environmental effects and contribute to conservation and recovery while contributing to cultural resources associated primarily with recreational and tribal fishing interests. See Chapter 4, Environmental Consequences, for a full analysis of predicted impacts of this alternative on the human environment.

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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 (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)

No other resources were identified during scoping that would have the potential to be significantly impacted by the Proposed Action or alternatives (Subsection 1.6, Scoping and Relevant Issues). Additionally, a review of available NEPA analyses of salmon and steelhead hatchery programs in Puget Sound watersheds including the Elwha FEA (NMFS 2012), PS Hatcheries DEIS (NMFS 2014a), Elwha FSEA (NMFS 2014b), EWS Hatcheries DEA (NMFS 2015a), and Dungeness Hatcheries DEA (NMFS 2015b), suggests that water quality and wildlife (other than Southern Resident killer whale) resources are unlikely to have the potential to be significantly impacted by the Proposed Action or alternatives. Therefore, analyses of water quality and wildlife (other than Southern Resident killer whale) in the above documents are incorporated by reference; thus there are no further analyses 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 the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins (Subsection 1.4, Project and Analysis Areas). Under existing conditions, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins produce up to 620,000 yearling smolts annually, as follows:

- Dungeness River basin: up to 10,000 yearlings
- Nooksack River basin: up to 150,000 yearlings

- Stillaguamish River basin: up to 130,000 yearlings
- Skykomish River basin: up to 256,000 yearlings
- Snoqualmie River basin: up to 74,000 yearlings

Since the entry of the Consent Decree in *Wild Fish Conservancy v. WDFW* (W.D. Wash.) on April 25, 2014, WDFW has not released these early winter steelhead smolts into waters connected to Puget Sound, with the exception of up to 180,000 smolts into the Skykomish River basin. However, the agreement not to release early winter steelhead smolts expires 2½ years after entry of the decree.

Because the Consent Decree applied only to the 2014 and 2015 release years, after many years of operation, the reduced numbers of early winter steelhead released for those 2 years would not be expected to have had a substantial impact on the analysis of the affected environment (i.e., existing environmental conditions). Consequently, existing environmental conditions are described in the context of the releases of salmon and steelhead shown in Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities.

The alternatives are likely to result in more direct, indirect, and cumulative effects to salmon and steelhead than to other resources. Consequently, this EIS contains more information on salmon and steelhead resources, and early winter hatchery-origin steelhead in particular, than on 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 beyond the locations of the hatchery facilities used to produce fish from the hatchery programs. Effects would also 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 project area is the geographic area where the Proposed Action would occur (Subsection 1.4, Project and Analysis Areas). It includes the places where early winter hatchery steelhead would be spawned, incubated, reared, acclimated, released, or harvested in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins (Subsection 1.4, Project and Analysis Areas). The analysis area for each resource includes the project area and each of the rivers to its confluence with the Puget Sound as a minimum area, but may include locations beyond the project area to fully analyze effects of various resources under the alternatives. The analysis area for each resource is described in Chapter 3, Affected Environment.

The effects of the hatchery programs under current 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.

3.1 Water Quantity

Hatchery programs can affect water quantity when they take water from a well (groundwater) or a neighboring river or tributary stream (surface water) to use in the hatchery facility for broodstock holding, egg incubation, juvenile rearing, and juvenile acclimation. All water, minus evaporation, that is diverted from a river or taken from a well is discharged into the water course adjacent to the hatchery rearing location after it circulates through the hatchery facility (non-consumptive use[1]). When hatchery programs use groundwater (i.e., from wells), they may reduce the amount of water for other users in the same aquifer. When hatchery programs use surface water, they 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 closely together as possible to minimize the area of the stream that may be impacted by a water withdrawal. Additional information on water quantity conditions in the analysis area associated with hatchery programs can be found in Subsection 3.6, Water Quality and Quantity, in the PS Hatcheries DEIS (NMFS 2014a).

As shown in Table 1, there are eight hatchery facilities currently used to support the five proposed early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. The early winter steelhead hatchery programs and associated hatchery facilities are:

• Dungeness River Program	Dungeness River Hatchery Hurd Creek Hatchery
• Kendall Creek Program	Kendall Creek Hatchery McKinnon Pond
• Whitehorse Ponds Program	Whitehorse Ponds Hatchery
• Snohomish/Skykomish Program	Wallace River Hatchery Reiter Ponds
• Tokul Creek Program	Tokul Creek Hatchery

[1] 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").

Four of the hatchery facilities use surface water exclusively (Dungeness River Hatchery, McKinnon Pond, Wallace River Hatchery, and Reiter Ponds), and four of the hatchery facilities use both groundwater and surface water (Kendall Creek Hatchery, Hurd Creek Hatchery, Whitehorse Ponds Hatchery, and Tokul Creek Hatchery). The description of the existing conditions for water quantity focuses on water quantity resources at these eight hatchery facilities where the action alternatives would occur.

A water right permit from the Washington Department of Ecology (Ecology) is required for all surface water and groundwater withdrawals except, in many cases, those supporting single-family homes. All water~~wells~~ use~~d~~ by hatchery facilities supporting the proposed early winter steelhead hatchery programs ~~are~~ is permitted by Ecology. Water available for use under water rights 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 rights permits.

Surface flows fluctuate seasonally, based on rainfall levels and snowmelt with flows generally highest in winter and spring. ~~Surface water withdrawal~~ 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 for fish health maintenance. 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 for fish health maintenance than they do during the winter and spring months.

Stream gauges are not ~~operated at each facility~~ 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 gauging stations nearest to each facility in the respective river basins, 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 4.

1 Table 4. Water use at the eight hatchery facilities that support five early winter steelhead programs in the Dungeness, Nooksack, Stillaguamish,
2 Skykomish, and Snoqualmie River Basins.

Hatchery Facility	Max Ground Water Use (cfs)	Max Surface Water Use (cfs)	Percent of Hatchery Facility Used to Rear Steelhead (%)[1]	Max Use of Water to Support Steelhead Programs (cfs)[2]	Surface Water Source	Annual Surface Water Flow (min/mean/max) (cfs)[3]	Max Percentage of Water Flow Diverted During Low Flow Conditions (%)[4]
Dungeness River Hatchery	NA	40.0	5	Surface: 2.0	Dungeness River	Min: 56 Mean: 397 Max: 3,310	3.6
	NA	8.5		Surface: 0.4	Canyon Creek	Min: 2 Mean: 8 Max: 2,025	20.0
Hurd Creek Hatchery	5	1.4	19	Ground: 0.95 Surface: 0.26	Hurd Creek	Min: 2 Mean: 5 Max: 2,007	13.0
Kendall Creek Hatchery	27.2	23.8	28	Ground: 7.7 Surface: 6.7	Kendall Creek	Min: 522 Mean: 3,847 Max: 43,700	1.3
McKinnon Pond	NA	2.0	100 from December through February	Surface: 2.0	Peat Bog Creek	Min: 32 Mean: 520 Max: 8,650	0.3 (note that steelhead are not reared in McKinnon Pond during low flow conditions so this is the proportion used during average flow conditions)
Whitehorse Ponds Hatchery	1.1	5.6	42	Ground: 0.5 Surface: 2.4	Whitehorse Spring Creek	Min: 123 Mean: 1,908 Max: 36,800	1.2
Wallace River Hatchery	NA[5]	40.0	16	Surface: 6.4	Wallace River	Min: 303 Mean: 3,985 Max: 88,400	0.7

Table 4. Water use at the eight hatchery facilities that support five early winter steelhead programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River Basins. (continued)

Hatchery Facility	Max Ground Water Use (cfs)	Max Surface Water Use (cfs)	Percent of Hatchery Facility Used to Rear Steelhead (%)[1]	Max Use of Water to Support Steelhead Programs (cfs)[2]	Surface Water Source	Annual Surface Water Flow (min/mean/max) (cfs)[3]	Max Percentage of Water Flow Diverted During Low Flow Conditions (%)[4]
	NA	14.0		Surface: 2.2	May Creek	Min: 303 Mean: 3,985 Max: 88,400	1.6
Reiter Ponds	NA	10.0	49	Surface: 4.9	Austin Creek	Min: 303 Mean: 3,985 Max: 88,400	1.6
	NA	10.0		Surface: 4.9	Hogarty Creek	Min: 303 Mean: 3,985 Max: 88,400	1.6
Tokul Creek Hatchery	NA	12.0	45	Surface: 5.4	Tokul Creek	Min: 303 Mean: 3,985 Max: 88,400	1.8
		6.0		Surface: 2.7	Unnamed spring		0.9

Sources: Maximum ground and surface water use levels are from Table 4.1.1 in HGMPs WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e.

[1] Percentages reflect the percent of the total production (in pounds) comprising steelhead, during times steelhead are reared at each facility.

[2] Flows to support steelhead are derived from values in the table by multiplying the maximum water use by the percent used to rear steelhead.

[3] Surface water source and flow data are from USGS stream gauging stations in the respective river basins 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 gauging stations are not available at each hatchery facility site. Information on each water source used is as follows. Dungeness River: October through September 5-year (2006-2011) mean, minimum, and maximum flow data for the lower Dungeness River from Washington Department of Ecology (WDOE 2012a) Dungeness River Stream Flow Monitoring Station 18A050, accessible at: https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?wria=18#block2 Flow data collection reach is downstream of five irrigation withdrawal points on the river. Additional source of flow data is Elwha Dungeness Planning Unit (EDPU 2005) available at: http://www.clallam.net/environment/elwhadungenesswria.html. Flows presented for the upper Dungeness River are the estimated incremental average annual flows from EDPU (2005). The Dungeness River Management Team recommended minimum instream flows for the lower Dungeness River at seasonal flow levels recommended by the Dungeness Instream Flow Group (Wampler and Hiss 1991; Hiss 1993): November through March: 575 cfs; April through July: 475 cfs; and August through October: 180 cfs. These minimum flows are not based on seasonal, historical Dungeness River flows, but represent flows required to maintain optimal potential fish habitat area (EDPU 2005). Stream gauge locations by river mile (RM): Nooksack RM 30.9 and Middle Fork Nooksack RM 5.6; North Fork Stillaguamish RM 6.5; Skykomish RM 43.0. Gallons-per-minute to cubic-feet-per-second conversion factor: cfs = gpm/7.48/60.

[4] Percentages are derived by dividing cfs values for maximum use of water for steelhead by the minimum surface water flows.

[5] NA = not applicable

The analysis area for water quantity is the same as the project area (Subsection 1.4, Project and Analysis Areas). The following sections summarize water withdrawals at the facilities that support the early winter steelhead programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins.

Dungeness River Basin: The Dungeness River Hatchery uses surface water exclusively, withdrawn through three water intakes on the Dungeness River and one on Canyon Creek, an adjacent tributary. The Hurd Creek Hatchery facility uses a combination of groundwater withdrawn from five wells, and surface water withdrawn from Hurd Creek as an emergency back-up source.

The Dungeness River Hatchery withdraws up to 2.0 cubic feet per second (cfs) of water from the Dungeness River and up to 0.4 cfs from Canyon Creek to support the Dungeness River early winter steelhead program (Table 4). All water (minus evaporation) is returned to the river after circulating through the hatchery. Water quantity is only affected between the water intake and discharge structures. Water flows in the Dungeness River average 397 cfs with minimum flows of 56 cfs. Because the early winter steelhead hatchery program diverts up to 2.0 cfs of water from the Dungeness River, which is 3.6 percent of the water in the Dungeness River during low flow conditions, effects of the water withdrawal are considered low under existing conditions. Water flows in Canyon Creek average 8.0 cfs with minimum flows of 2.0 cfs. Because the early winter steelhead hatchery program diverts up to 0.26 cfs of water, which is 20 percent of the water in Canyon Creek during low flow conditions, the water withdrawal is assessed as a moderate negative effect under existing conditions.

The Hurd Creek Hatchery withdraws up to 0.26 cfs from Hurd Creek and 0.95 cfs from five wells to support the Dungeness River early winter steelhead program (Table 4). All water (minus evaporation) is returned to the creek after circulating through the hatchery. Water quantity is only affected between the water intake and discharge structures. Water flows in Hurd Creek average 5.0 cfs with minimum flows of 2.0 cfs. Because the early winter steelhead hatchery program diverts up to 0.26 cfs of water from Hurd Creek, which is 13 percent of the water in Hurd Creek during low flow conditions, the water withdrawal is assessed as a moderate negative effect under existing conditions. In addition, the withdrawal of 0.95 cfs of the maximum of 5 cfs that is permitted from five wells (Table 4) is assessed as a low negative effect on groundwater under existing conditions.

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

Nooksack River Basin: The Kendall Creek Hatchery uses well and surface water (when available). The McKinnon Pond uses gravity fed surface water from a stream locally known as "Peat Bog Creek" (WRIA 01.0352).

The Kendall Creek Hatchery withdraws up to 6.7 cfs from Kendall Creek and 7.7 cfs from wells to support the Kendall Creek early winter steelhead program (Table 4). All water (minus evaporation) is returned to the creek after circulating through the hatchery. Water quantity is only affected between the water intake and discharge structures. Water flows in Kendall Creek average 3,847 cfs with minimum flows of 522 cfs. Because the early winter steelhead hatchery program diverts up to 6.7 cfs of water from Kendall Creek, which is 1.3 percent of the water in Kendall Creek during low flow conditions, the water withdrawal has a negligible negative effect under existing conditions. In addition, the withdrawal of 7.7 cfs of the maximum of 27.2 cfs that is permitted (Table 4) is assessed as a low negative effect on groundwater under existing conditions.

The McKinnon Pond may withdraw up to 2.0 cfs from Peat Bog Creek from December through February to rear early winter steelhead (Table 4). Steelhead are not reared in McKinnon Pond during the remainder of the year. All water (minus evaporation) is returned to the creek after circulating through the rearing pond. Water quantity is only affected between the water intake and discharge structures. Water flows in Peat Bog Creek average 520 cfs with minimum flows of 32 cfs. Because the early winter steelhead hatchery program diverts up to 2.0 cfs of water from Peat Bog Creek, which is 0.3 percent of the water in Peat Bog Creek during average flow conditions, the water withdrawal is assessed as a negligible negative effect under existing conditions.

Monitoring and measurement of water usage are reported by the applicant in monthly NPDES permit reports to Ecology.

Stillaguamish River Basin: Whitehorse Ponds Hatchery uses well and surface water. The Whitehorse Ponds Hatchery withdraws up to 2.4 cfs from Whitehorse Springs Creek and up to 0.5 cfs from wells to support the early winter steelhead hatchery program (Table 4). All water (minus evaporation) is returned to the creek after circulating through the hatchery. Water quantity is only affected between the water intake and discharge structures. Water flows in Whitehorse Springs Creek average 1,908 cfs with minimum flows of 123 cfs. Because the early winter steelhead hatchery program diverts up to 2.4 cfs of water from Whitehorse Springs Creek, which is 1.2 percent of the water in Whitehorse Springs Creek during low flow conditions, the water withdrawal has a negligible negative effect under existing conditions. In addition, the withdrawal of 0.5 cfs of the maximum of 1.1 cfs that is permitted (Table 4) is assessed as a low negative effect on groundwater under existing conditions.

Monitoring and measurement of water usage are reported by the applicant in monthly NPDES permit reports to Ecology.

Skykomish River Basin: The Wallace River Hatchery uses only surface water. The Wallace River Hatchery has two water intake structures, one on the Wallace River and one on May Creek. The Wallace River Hatchery withdraws up to 6.4 cfs from Wallace River and up to 2.2 cfs from May Creek to support the early winter steelhead hatchery program (Table 4). All water (minus evaporation) is returned to the river after circulating through the facilities. Water quantity is only affected between the water intakes and discharge structures. Water flows in the Wallace River average 3,985 cfs with minimum flows of 303 cfs. Because the early winter steelhead hatchery program diverts up to 6.4 cfs of water from the Wallace River and 2.2 cfs from May Creek, which is 0.7 percent of the water in the Wallace River and 1.6 percent of the water in May Creek during low flow conditions, the water withdrawals are assessed as a negligible negative effect under existing conditions.

Reiter Ponds also has two intakes structures (one on Austin Creek and one on Hogarty Creek). Reiter Ponds withdraws up to 4.9 cfs from Austin Creek and up to 4.9 cfs from Hogarty Creek to support the early winter steelhead hatchery program (Table 4). All water (minus evaporation) is returned to the creeks after circulating through the facilities. Water quantity is only affected between the water intakes and discharge structures. Water flows in Austin Creek and Hogarty Creek average 3,985 cfs, with minimum flows of 303 cfs each. Because the Reiter Ponds early winter steelhead hatchery program diverts up to 4.9 cfs of water from each creek, which is 1.6 percent of the water in from either Austin Creek and Hogarty Creek during low flow conditions, the water withdrawal is assessed as a negligible negative effect under existing conditions.

Monitoring and measurement of water usage are reported by the applicant in monthly NPDES reports to Ecology.

Snoqualmie River Basin: The Tokul Creek Hatchery uses surface water. The Tokul Creek Hatchery withdraws up to 5.4 cfs from Tokul Creek and up to 2.7 cfs from a spring to support the early winter steelhead hatchery program (Table 4). All water (minus evaporation) is returned to the creek after circulating through the hatchery. Water quantity is only affected between the water intake and discharge structures. Water flows in Tokul Creek average 3,985 cfs with minimum flows of 303 cfs. Because the early winter steelhead hatchery program diverts up to

5.4 cfs of water from Tokul Creek, which is 1.8 percent of the water in Tokul Creek during low flow conditions, the water withdrawal has a negligible negative effect under existing conditions. In addition, the withdrawal of 0.9 cfs is assessed as a negligible negative effect on the spring source under existing conditions.

Monitoring and measurement of water usage are reported by the applicant in monthly NPDES reports to Ecology.

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 in the river basins associated with the proposed early winter 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 1991, 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; 72 Fed. Reg. 26722, May 11, 2007; 76 Fed. Reg. 50488, August 5, 2011). There are four additional non-listed salmon species in Puget Sound (fall chum salmon, pink salmon, sockeye salmon, and coho salmon).

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). Table 5 summarizes which salmon and steelhead species are found in the analysis area.

Critical habitat has been designated for Puget Sound Chinook salmon (70 Fed. Reg. 52630, September 2, 2005) and Hood Canal summer chum salmon (70 Fed. Reg. 52630). NMFS has proposed designation of critical habitat for Puget Sound steelhead (78 Fed. Reg. 2726, January 14, 2013). Critical habitat has not been designated for fall chum salmon, pink salmon, and coho salmon because these species are not listed under the ESA. The analysis area includes critical habitat for Puget Sound Chinook salmon and Hood Canal summer chum salmon and proposed critical habitat for Puget Sound steelhead.

Table 5. A summary of natural-origin salmon and steelhead populations in the analysis area.

Species or Stock	Listing Status under ESA	Dungeness River Basin	Nooksack River Basin	Stillaguamish River Basin	Snohomish River Basin	Occurrence in Puget Sound Marine Areas
Spring/Summer Chinook Salmon	Threatened	X	X	X	X	X
Fall Chinook Salmon	Threatened		X	X	X	X
Summer Chum Salmon	Threatened	X				X
Winter Steelhead[1]	Threatened	X	X	X	X	X
Summer Steelhead	Threatened		X	X	X	X
Fall Chum Salmon	Not listed	X	X	X	X	X
Pink Salmon	Not listed	X	X	X	X	X
Coho Salmon	Not listed	X	X	X	X	X
Sockeye Salmon	Not listed	~~X~~	X[2]	X[2]		X

[1] Although populations of steelhead in the Puget Sound DPS include both summer and winter run life history types, the DPS is composed primarily of winter run populations (Myers et al. 2015).
[2] It is unknown whether the sockeye salmon in the Nooksack and Stillaguamish River basins are self-sustaining riverine stocks or if they represent strays from adjacent watersheds where self-sustaining sockeye populations are present.

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

Although Subsection 3.2, Salmon and Steelhead, is focused on the effects of five early winter steelhead hatchery programs on listed and non-listed salmon and steelhead in the analysis area, 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, ~~previous~~ NMFS salmon status reviews (Myers et al. 1998; Good et al. 2005; Ford 2011; NWFSC 2015), recovery plans (72 Fed. Reg. 2493, January 19, 2007; 72 Fed. Reg. 29121, May 24, 2007), and other documents (WSCC 2005), describe a range of past and current factors that have 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, and increased flooding. In marine areas, these modifications have altered shorelines and reduced the physical and ecological complexity of estuarine areas, therefore compromising areas used for salmon and steelhead feeding, migration, and rearing.

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

Predation: Direct and indirect[2] predation by native and introduced aquatic, terrestrial, and avian species result in salmon and steelhead mortality.

Oceanic Conditions: Broad-scale, cyclic changes in climatic and ocean conditions drive salmon productivity (e.g., El Niño events), and may produce density-dependent[3] effects that are important to how and where populations of salmon are sustained over the short and long term (e.g., 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).

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 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 2011b). All of the past and current factors as described above have negatively affected salmon and steelhead populations, distribution, and overall survival.

The most recent 5-year status review (NWFSC 2015) found that the biological risks faced by the Puget Sound Steelhead DPS have not substantively changed since the listing in 2007, or since the last status review (Ford 2011). NWFSC (2015) noted the recent years when temperatures of marine waters and streams were especially warm and thus, unfavorable for high marine or freshwater survival. Using various

[2] 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.

[3] 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.

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, including those in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, are 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) and the Final Environmental Impact Statement to Inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs – herein referred to as the Mitchell Act Hatcheries FEIS (NMFS 2014c), describe in more detail these general mechanisms, and both are incorporated by reference (Subsection 1.1.3, Related National Environmental Policy Act Reviews), to this EIS.

Based on a review of hatchery plans currently submitted to NMFS, the co-managers release a total of about 160 million juvenile hatchery-origin salmon and steelhead into Puget Sound freshwater and marine areas each year, including 47.4 million Chinook salmon, 14.9 million coho salmon, 50 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 similar to the total Puget Sound production level of 147 million salmon and steelhead that was analyzed in the PS Hatcheries DEIS (NMFS 2014a). Thus, 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, then 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.

The PS Hatcheries DEIS (NMFS 2014a) described effects based on production levels of 45.3 million Chinook salmon, 14.6 million coho salmon, 45 million fall 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 Y, shows the differences in production levels between the PS Hatcheries DEIS (NMFS 2014a) and ~~this EIS~~current production levels (Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities).

Table Y. 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)	47,497 (30)
Coho Salmon	14,592 (10)	14,922 (9)
Steelhead	2,468 (2)	1,243 (1)
Chum Salmon	44,995 (30)	50,025 (31)
Pink Salmon	4,500 (3)	4,100 (3)
Sockeye Salmon	35,125 (24)	42,340 (26)
Total	**146,997 (100)**	**160,127 (100)**

With ~~only one~~ two exceptions (chum salmon and sockeye salmon), current hatchery releases are lower than (steelhead) or similar to~~within~~ the range of releases levels analyzed in the PS Hatcheries DEIS (NMFS 2014a). Lower release levels for steelhead are due primarily to program terminations, whereby the current release level of hatchery-origin steelhead has been reduced from the 2.5-million level analyzed in the PS Hatcheries DEIS (NMFS 2014a) to 1.2 million while still comprising a small percentage (1 to 2 percent) of the total salmon and steelhead production in Puget Sound. Current chum salmon release levels are higher than those analyzed in the PS Hatcheries DEIS (NMFS 2014a) because the number of fish released from the Keta Creek hatchery program (Duwamish/Green River), Kendall Creek hatchery program (North Fork Nooksack River), and McKernan hatchery program (Skokomish River) is greater than the release levels analyzed in the PS Hatcheries DEIS. Current sockeye salmon release levels are higher than those analyzed in the PS Hatcheries DEIS (NMFS 2014a) because of increased releases in one of the two sockeye salmon programs in the analysis area – Baker River. In Puget Sound, run size and escapement monitoring indicate that for recent years, hatchery-origin fish make up 76 percent of total adult returns of Chinook salmon, 47 percent of coho salmon, 29 percent of fall chum salmon, 30 percent of sockeye salmon, 2 percent of pink salmon, and an unknown proportion of total steelhead returns (PS Hatcheries DEIS [NMFS 2014a]).

The general mechanisms through which hatchery programs can affect natural-origin salmon and steelhead populations are described in Table 6 below. These effects are also described in Chapter 3, Affected

Environment, and Appendix H, Steelhead Effects Analysis by Basin, in the PS Hatcheries DEIS (NMFS 2014a).

Table 6. General mechanisms through which hatchery programs can affect natural-origin salmon and steelhead populations.

Effect Category	Description of Effect
Genetic Risks	• Interbreeding with hatchery-origin fish can change the genetic character of the local salmon or steelhead populations. • Interbreeding with hatchery-origin fish may reduce the reproductive performance of the local salmon or steelhead 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.
Hatchery Facility Effects	• 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 Effects	• Fisheries targeting hatchery-origin fish have incidental impacts on natural-origin fish.
Disease Transfer	• 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.
Mining	• Use of natural-origin fish for broodstock can reduce the abundance and spatial structure of the natural-origin population.
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: Hatchery programs could increase the productivity of a natural-origin population if naturally spawning hatchery- origin fish match natural-origin fish in reproductive fitness and when the natural-origin population's abundance is low enough to limit natural-origin productivity (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.

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). In the PS Hatcheries DEIS (NMFS 2014a), the No-action Alternative identified potential effects to 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 the project area at the time of the analysis (Alternative 1 in Table S-4 in PS Hatcheries DEIS [NMFS 2014a]). For the listed Puget Sound Steelhead DPS, that analysis 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, the competition risk is moderate, genetic risk is low, and hatchery facilities risk (including disease transfer) is low (PS Hatcheries DEIS [NMFS 2014a]). Similarly, total salmon and steelhead production poses a moderate risk and low benefit to the listed Puget Sound Chinook salmon ESU. For that ESU overall, the competition risk in freshwater is moderate, predation risk in freshwater (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]).

Updated information on genetic risks (e.g., gene flow) to natural-origin steelhead associated with past practices (prior to the HGMPs associated with the Proposed Action) and as projected based on current practices (current HGMPs) is found in Subsection 3.2.3.1, Genetic Risks, and Appendix B, Genetic Effects Analysis of Early Winter Steelhead Programs Proposed for the Nooksack, Stillaguamish, Dungeness, Skykomish, and Snoqualmie River Basins of Washington. Appendix B (see Table B-7) also describes genetic risk from summer steelhead hatchery programs (reflecting past practices) as likely high to natural-origin steelhead populations (for Stillaguamish River winter steelhead), and low to moderate to Skykomish River winter steelhead. Natural-origin summer steelhead in the North Fork Skykomish River and Tolt River are likely offspring of hatchery-origin summer steelhead. Genetic impacts to natural-origin steelhead from past production of hatchery-origin summer-run steelhead have been measurable, but practices have been recently modified to reduce this effect (Appendix B, Section 2.6).

For non-listed natural-origin salmon species (coho salmon, fall 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 freshwater 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 Chum Salmon) in the PS Hatcheries DEIS (NMFS 2014a), releases of pink salmon pose competition risks to fall-run 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 freshwater (and are possible in marine waters) from the larger yearling hatchery-origin Chinook 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 freshwater 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 freshwater (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 only two sockeye salmon hatchery programs in the analysis area.

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 (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.

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 (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]).

3.2.2.3 Salmon and Steelhead Hatchery Programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River Basins

The river basins that support the five early winter steelhead programs are also ~~where~~ home to several other hatchery programs ~~are located~~. WDFW and three Puget Sound treaty tribes operate 25 additional salmon hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins.

Dungeness River Basin Hatchery Programs: There are three additional salmon hatchery programs in the Dungeness River basin, as described in the Dungeness Hatcheries DEA (NMFS 2015b). WDFW, with some funding assistance from the Jamestown S'Klallam Tribe, operates three salmon hatchery programs in the Dungeness River basin. Two programs operate for conservation-directed supplementation purposes, and one program produces coho salmon largely to provide fish for harvest. The Dungeness River hatchery programs are operated to conserve at-risk native salmon populations (Chinook salmon and pink salmon) and partially mitigate for lost natural-origin fish production largely resulting from past and on-going loss and degradation of natural fish habitat, and impending climate change

Nooksack River Basin Hatchery Programs: There are 12 additional salmon hatchery programs operating in the Nooksack River basin, of which two are operated cooperatively by WDFW and the Lummi Nation for stock conservation purposes, with the remainder implemented by WDFW (five programs) and the Lummi Nation (five programs) to provide fish for harvest. All of the hatchery programs in the Nooksack River basin operate to partially offset natural-origin salmon and steelhead population reductions resulting from past and on-going land-use practices, including forestry and agriculture (SSPS 2005

Stillaguamish River Basin Hatchery Programs: There are four additional salmon hatchery programs in the Stillaguamish River basin. WDFW operates one additional salmon hatchery program (operated jointly with the Stillaguamish Tribe of Indians for conservation purposes), and the Stillaguamish Tribe of Indians operates an additional three programs (one for stock conservation and two for harvest augmentation). These hatchery programs operate in the Stillaguamish River basin to offset existing severe constraints on natural-origin fish production due to poor freshwater habitat conditions (Stillaguamish 2007). WDFW operates one program in the Stillaguamish River basin that produces summer-run steelhead from broodstock that originated in the Skamania River basin; this is an isolated program that produces fish for harvest.

Skykomish River Basin Hatchery Programs: There are six additional hatchery programs operating in the Snohomish/Skykomish River basin. The Tulalip Tribes operate three programs for harvest augmentation, and WDFW operates two programs and one net pen for harvest augmentation. These hatchery programs operate in the Skykomish River basin to offset constraints on natural-origin fish production due to poor habitat conditions (Tulalip 2012, 2013a, 2013b; WDFW 2013a, 2013b, 2013c). There is one summer-run steelhead hatchery program operated by WDFW in the Skykomish River basin. As with the summer-run program in the Stillaguamish River basin, this program uses Skamania stock to provide fish for harvest.

Snoqualmie River Basin Hatchery Programs: No hatchery programs operate in the Snoqualmie River basin other than the early winter steelhead program at the Tokul Creek Hatchery.

Salmon and winter-run and summer-run steelhead hatchery programs and facilities operating throughout the analysis area (including integrated winter-run programs in the Elwha River, Hood Canal, Green River, White River), are described in Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities, and their effects on the salmon and steelhead resource are described in Subsection 3.2.2.2, Existing Conditions and Effects of Current Salmon and Steelhead Hatchery Programs in Puget Sound.

3.2.2.4 Background on Existing Early Winter Steelhead Hatchery Programs

Steelhead hatchery programs in Puget Sound were initiated in the early 1900s to augment harvest opportunity in their respective river basins. Beginning in ~~1935~~ 1945, steelhead returning to Chambers Creek (trapped from February through April) were used to establish a hatchery stock that was subsequently released throughout much of Puget Sound (Crawford 1979), including in the Nooksack (Kendall Creek Hatchery beginning in 1998), Stillaguamish (Whitehorse Ponds Hatchery in 1964), and Dungeness River basins (Dungeness River Hatchery in 1995), Snoqualmie River (Tokul Creek Hatchery in 1951), and Skykomish River basins (Wallace River Hatchery in 1999) (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e). Advances in fish cultural techniques in the 1960s led to further development of the Chambers Creek hatchery-origin stock (also known as the early winter steelhead stock) through broodstock selection and accelerated rearing (Crawford 1979). Currently, a total of about 1.2 million hatchery-origin winter-run and summer-run steelhead are released into Puget Sound rivers (Table 6; Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities).

The early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins are isolated[4] hatchery programs that seek to minimize interactions between hatchery-origin and natural-origin fish. The programs are not designed to augment the abundance of natural spawners and do not contribute to the population viability or recovery of listed steelhead; they are designed to contribute to harvest in their respective river basins while minimizing negative impacts on natural-origin populations. Since Puget Sound steelhead were listed under the ESA, several risk reduction measures have been implemented in early winter steelhead hatchery programs in Puget Sound (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e)~~.~~ including:

- Greater than 50 percent reduction in total number of early winter hatchery-origin steelhead released in the Puget Sound tributaries
- Greater than 65 percent reduction in the number of early winter steelhead release locations
- Elimination of cross-basin transfers, off-station releases, and adult recycling
- Volitional smolt releases to ensure the fish are ready to migrate out of the freshwater system, thus minimizing the amount of time for ecological interactions between hatchery-origin and natural-origin fish
- Hatchery broodstock collection by January 31 to enhance separation between hatchery-origin steelhead and the later-returning, native natural-origin steelhead populations
- Genetic monitoring of steelhead
- Hatchery traps now remain open through March 15 (or later as conditions allow) to provide the opportunity for all adult hatchery-origin fish to return to the hatcheries to reduced straying
- Eggs are only collected from fish that return to the hatchery to promote fidelity of homing to the hatcheries

[4] In an isolated hatchery program the hatchery-origin population is reproductively segregated from the natural-origin population, in particular by using only hatchery fish for broodstock, and other practices. These programs produce fish that are different from local populations. These programs do not contribute to conservation or recovery of populations included in an ESU or DPS. Isolated programs are also called segregated programs.

Because of changes such as these, the most recent 5-year status review concluded that the risk posed by steelhead hatchery programs to the DPS has declined since the previous 5-year status review (NWFSC 2015).

3.2.3 Effects of Current Early Winter Steelhead Hatchery Programs on Salmon and Steelhead

The affected environment associated with the past and current operation of the five early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins is discussed in Subsection 3.2.3.1, Genetic Risks, through Subsection 3.2.3.9, Nutrient Cycling.

3.2.3.1 Genetic Risks

Hatchery-origin steelhead do not interbreed with salmon species and, therefore, do not pose a genetic risk to natural-origin salmon populations. Consequently, there are no genetic risks to salmon species from early winter steelhead hatchery programs; therefore, genetic risks to salmon are not analyzed in this EIS. Detailed information on genetic risks of early winter steelhead hatchery programs and early summer steelhead (Skamania stock) hatchery programs to natural-origin steelhead can be found in Appendix B, Genetic Effects Analysis of Early Winter Steelhead Programs Proposed for the Nooksack, Stillaguamish, Dungeness, Skykomish, and Snoqualmie River Basins of Washington. Additional information on genetic risks of hatchery programs to salmon and steelhead can be found in Subsection 2.1.3, Genetics, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a).

As described in Subsection 3.2, Salmon and Steelhead, the five Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie early winter steelhead hatchery programs operate as isolated hatchery programs and produce fish that are derived from Chambers Creek steelhead, a non-local stock whose time of return and spawning has been advanced through fish culture practices (i.e., hatchery-influenced selection, sometimes called domestication). Although the hatchery-origin steelhead from these five isolated hatchery programs return and spawn earlier than the natural-origin steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, and thus not at the optimal time for successful reproduction, they may have some success spawning in the wild (e.g., Jones et al. 2015). In addition, there may be overlap in timing between the latest spawning early winter hatchery-origin steelhead and the earliest spawning winter-run steelhead (Figure 1). For more detail on spawner overlap see Appendix B, Genetic Effects Analysis of Early Winter Steelhead Programs Proposed for the Nooksack, Stillaguamish, Dungeness, Skykomish, and Snoqualmie River Basins of Washington; Seamons et al. (2012); and McMillan (2015a, 2015b). This potential overlap creates the potential for interbreeding between early winter hatchery-origin steelhead from the proposed five hatchery programs and natural-origin steelhead found in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. The traits that are intentionally and inadvertently selected for in the hatchery environment (e.g., early spawn~~run~~ timing) make early winter hatchery-origin steelhead ill-suited for survival and productivity in the natural environment. Therefore, any successful reproduction of early winter steelhead, especially interbreeding between early winter hatchery-origin steelhead and natural-origin steelhead, may have affected the genetic integrity and productivity of natural-origin steelhead populations in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins.

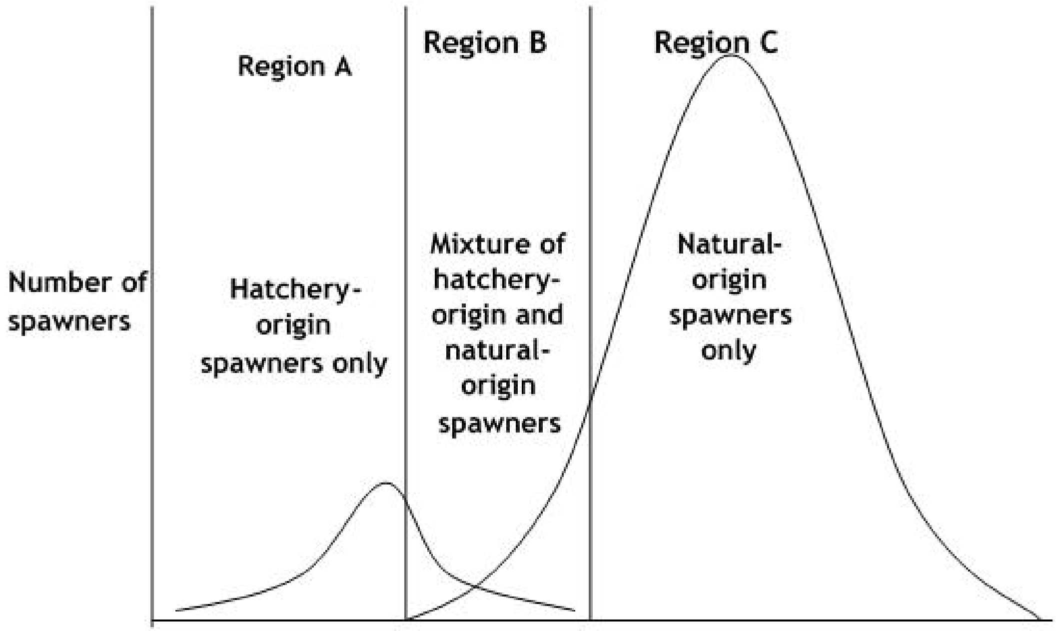

Figure 1. Schematic of temporal spawning overlap between early winter hatchery steelhead and natural-origin winter steelhead. Shape, sizes and placement of curves is conceptual and is not meant to represent any specific situation (Scott and Gill 2008, Fig. 4-7).

As described in Subsection 3.2.2.2, Existing Conditions and Effects of Current Salmon and Steelhead Hatchery Programs in Puget Sound, hatchery-origin summer-run steelhead are also released in two of the watersheds where early winter steelhead are released (Stillaguamish and Skykomish River basins), and gene flow from them into the natural-origin winter steelhead populations has occurred (Appendix B, Genetic Effects Analysis of Early Winter Steelhead Programs Proposed for the Nooksack, Stillaguamish, Dungeness, Skykomish, and Snoqualmie River Basins of Washington). Similar to the early winter steelhead hatchery programs, these two summer-run programs produce steelhead solely for harvest, and the broodstock was originally derived from the Skamania River basin.

NMFS considered available guidelines in analyzing genetic risks associated with the alternatives. In 2004, the HSRG released its recommendations for hatchery reform (HSRG 2005). While not addressing the early winter steelhead hatchery programs specifically in their guidelines, the HSRG discussed risks posed by highly diverged hatchery stocks and concluded that ". . . if non-harvested fish spawn naturally, then these isolated programs can impose significant genetic risks to naturally spawning populations. Indeed, any natural spawning by fish from these broodstocks may be considered unacceptable because of the potential genetic impacts on natural populations . . . to minimize these risks, isolated hatchery programs need to be located in areas where virtually all returning adults can be harvested or recaptured, or where natural spawning or ecological interactions with natural-origin fish are considered minimal or inconsequential" (HSRG 2005). In 2009, the HSRG recommended that primary populations (those of high conservation concern) affected by isolated hatchery programs have a proportion of hatchery-origin spawners (pHOS) of no more than 5 percent (HSRG 2009)[5]. The HSRG recommended that integrated[6] hatchery programs affecting primary populations have a Proportionate Natural Influence (PNI)[7] of 0.67 (HSRG 2009). More recently, the HSRG suggested that perhaps pHOS levels should be lower than

[5] pHOS is the proportion of natural spawners that consist of hatchery-origin fish, and is a surrogate measure for gene flow. WDFW has developed two additional methods for directly measuring for gene flow: (1) the Warheit method, which uses genetic data to estimate proportionate effective hatchery contribution (PEHC) (Warheit 2014a) and (2) a demographic method, referred to as demographic gene flow (*DGF*) using the Scott-Gill method (Scott and Gill 2008).

[6] 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.

[7] 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.

5 percent for isolated programs and suggested that an effective pHOS level of 2 percent would be more appropriate for some programs based on their 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 better measure of potential gene flow from hatchery programs. Ideally, effective pHOS equals gene flow. However, because of the unique nature of the early winter steelhead programs, this assumption likely overestimates the effects of gene flow. Ultimately, the concern with gene flow is that it can reduce the fitness of HxN progeny and the affected naturally spawning population generally. To address the relationship of gene flow to fitness, specifically for the 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, Section 2.1. ~~As a result, based on available information~~ Based on this exercise, NMFS concludes that early winter steelhead isolated programs with a ~~pHOS~~ gene flow of less than 2 percent pose a low genetic risk to the fitness of natural-origin steelhead populations (Appendix B, Genetic Effects Analysis of Early Winter Steelhead Hatchery Programs Proposed for the Nooksack, Stillaguamish, Dungeness, Skykomish, and Snoqualmie River Basins of Washington). ~~and i~~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. WDFW's current statewide steelhead management plan is consistent with ~~the HSRG's recommendations~~ NMFS' findings for 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)~~ (note that pHOS is a surrogate metric for gene flow)~~. ~~This conclusion~~ 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 steelhead spawning (and pHOS) are difficult because high spring flows and associated turbidity hamper detection of spawners and redds. 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, currently it appears, based on genetic data (proportionate effective hatchery contribution [*PEHC*] Warheit Method), that gene flow into the Nooksack, Stillaguamish, and Skykomish basins is under 2 percent (Table 7). Using another method (demographic gene flow [*DGF*], referred to as the Scott Gill Method in the draft EIS), based on demographic information, gene flow into these ~~two~~ three basins and the Dungeness River basin is also estimated to be under 2 percent (Table 7; Table B-6 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). Using both methods, based on recent past practices (e.g., the last 5-10 years), gene flow into the Snoqualmie River basin is above 2 percent but below 5 percent. Therefore, there is a low negative effect to natural-origin steelhead population from early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, and Skykomish River basins, and a low to moderate negative effect to the natural-origin population in the Snoqualmie River basin.

Table 7. Summary of analyses of gene flow from five Puget Sound early winter steelhead hatchery programs into listed steelhead populations, based on recent past practices (e.g., the last 5-10 years).

River Basin	Listed Population[1]	PEHC~~Warheit Method (PEHC)~~ (%)	DGF~~Scott Gill Method (Gene Flow)~~ (%)
Nooksack	Nooksack (W)	1~~0~~ (0-4~~2~~)	0.37~~57~~ (1.46)
	SF Nooksack (S)	0 (0-7~~2~~)	-
Stillaguamish	Stillaguamish (W)	0 (0-7)	0.50~~1.05~~ (3.07)
	Deer Creek (S)	0 (0-3~~1~~)	-
	Canyon Creek (S)	0 (0-5~~2~~)	-
Dungeness	Dungeness (S/W)	-	0.34~~50~~ (0.82)
Snohomish/Skykomish	Pilchuck (W)	1 (0-16~~2~~)	~~0.0~~
	Skykomish (W)	0 (0-20)	1.21~~1.70~~ (4.62)
	North Fork Skykomish (S)	1 (1-3)	-
Snoqualmie	Snoqualmie (W)	4 (0-12)	3.98~~2.93~~ (14.91)
	Tolt (S)	1 (0-3)	-

Sources: Appendix B; Warheit 2014a; Warheit 2014b; Scott and Gill 2008; Hoffman 2015a; Hoffman 2015b.
[1] W = winter-run; S = summer-run.

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 between different species of salmon and steelhead. Detailed information on competition and predation risks of hatchery programs to natural-origin salmon and steelhead can be found in Subsection 2.1.1, Competition, and Subsection 2.1.2, Predation, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a).

The five Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basin early winter steelhead hatchery programs release steelhead at the yearling smolt stage, and they have the potential to compete with or predate on other salmon and steelhead (Table 8).

Table 8. Ecological relationship between hatchery-origin steelhead and natural-origin salmon and steelhead in the analysis area.

Species	Ecological Relationship with Hatchery-origin Steelhead			Location of Ecological Interaction		
	Predator of Hatchery-Origin Steelhead	Competitor with Hatchery-Origin Steelhead	Prey of Hatchery-Origin Steelhead	Freshwater	Estuary	Marine
Spring Chinook Salmon		X		X	X	
Fall Chinook Salmon			X	X	X	Unknown
Summer Chum Salmon[1]						
Winter Steelhead		X		X	X	
Summer Steelhead		X		X	X	
Fall Chum Salmon			X	X	X	Unknown
Pink Salmon			X	X	X	Unknown
Coho Salmon		X		X	X	
Sockeye Salmon			X	X	X	Unknown

[1] No relationships because Dungeness Hatchery steelhead are released after any natural-origin summer chum have emigrated seaward. Summer chum are not present in the Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins.

When space and/or food are limited, h~~H~~atchery-origin steelhead smolts likely compete with natural-origin steelhead, Chinook salmon, and coho salmon smolts in the freshwater and estuary areas (Table 8), because they are a similar size and would likely eat similar prey. Competition between hatchery-origin steelhead smolts and natural-origin salmon and steelhead smolts is not expected to occur in the marine areas because, once steelhead smolts enter the marine environment, the fish tend to move directly offshore into areas where steelhead are dispersed and not present in numbers that would contribute to density-dependent effects (Hartt and Dell 1986; Light et al. 1989). Recent information indicates steelhead smolts out-migrate promptly through Puget Sound (e.g., Moore et al. 2015).

Hatchery-origin steelhead smolts may directly prey upon juvenile natural-origin salmonids at several stages of their life history. Newly released hatchery-origin smolts have the potential to consume naturally produced fry and fingerlings that are encountered in freshwater during downstream migration. Some reports suggest that hatchery-origin fish can prey on fish that are up to one half of their length (Pearsons and Fritts 1999; HSRG 2005), but other studies have concluded that salmonid predators prey on fish one third or less of their length (Horner 1978; Hillman and Mullan 1989; Beauchamp 1990; Cannamela 1992; CBFWA 1996). Hatchery-origin steelhead that do not emigrate and instead take up~~stream~~ residence near the point of release (residuals) have the potential to prey on rearing natural-origin juvenile fish over a more prolonged period. Effects to natural-origin salmon and steelhead from indirect predation may occur when predators are attracted to concentrations of more abundant hatchery-origin fish and consume the less abundant natural-origin fish that are intermingled with the hatchery-origin fish. Due to the relatively small size and disbursed nature of early winter steelhead smolt releases, the risk of indirect predation to salmon and steelhead from the releases is likely negligible.

Therefore, the risk of hatchery-origin steelhead predation on natural-origin juvenile fish in freshwater and the estuary is dependent upon three factors: (1) the hatchery-origin steelhead~~fish~~ and their potential natural-origin prey must overlap temporally; (2) the hatchery-origin steelhead~~fish~~ and their prey must overlap spatially; and (3) the prey should be less than one third of the length of the predatory steelhead~~fish~~. Based on comparative fish sizes and timings, early winter steelhead smolts that would be released through the hatchery programs would have spatial and temporal overlap in freshwater and the estuary with smaller subyearling Chinook salmon, fall chum salmon fry, pink salmon fry, and potentially sockeye salmon fry. When combined with spatial and temporal overlap, the large average size of the early winter steelhead smolts poses a risk of predator-prey interactions in freshwater and the estuary for these species and life stages. It is unknown whether these predation risks continue after the species have emigrated from fresh water and dispersed in marine areas. The few diet studies that have been conducted in Puget Sound indicate that the predation risk posed by larger hatchery-origin fish to juvenile salmon is low (Buckley 1999; WDFW 2013a). Sharpe et al. (2008) and Naman and Sharpe (2012) found that hatchery-origin steelhead prey on other juvenile salmonid to a very low degree during their migration seaward. Further, the risks of predation effects are temporary because hatchery-origin steelhead disperse seaward within a few weeks after their release. In summary, p~~P~~redation may be low for the following reasons: (1) due to rapid growth, natural-origin salmon are better able to elude predators and are accessible to a smaller proportion of predators due to size alone; (2) because juvenile salmon disperse soon after entering seawater, they are present in low densities relative to other fish species (e.g., herring); and (3) there has either been learning or selection for some predator avoidance (Cardwell and Fresh 1979).

3.2.3.3 Hatchery Facility Risks

Operating hatchery facilities can impact instream fish habitat in the following ways: (1) reduction in available fish habitat from 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).

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, Water Quantity. 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).

The five early winter steelhead programs (and 25 hatchery programs for salmon, Subsection 3.2.2.3, Salmon Hatchery Programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River Basins) in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins use hatchery facilities that have several instream structures such as water intakes, fish ladders, and weirs. All hatchery intakes on salmon and steelhead streams are screened to prevent fish injury from impingement or permanent removal from streams. NMFS's 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 2011a). 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's 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.

McKinnon Pond and Tokul Creek Hatchery water intakes are screened consistent with NMFS's 2011 screening criteria (Table 9). Hurd Creek Hatchery, Kendall Creek Hatchery, Whitehorse Ponds Hatchery, Wallace Hatchery, and Reiter Ponds are screened consistent with older NMFS screening criteria. Screening for the Dungeness River Hatchery's water intake structures (one on the Dungeness River and one on Canyon Creek) are in compliance with NMFS's 2011 screening criteria, but are not in compliance with NMFS's fish passage criteria. The Canyon Creek water intake to the Dungeness River Hatchery is adjacent to a small dam that until recently completely blocked access to upstream salmon spawning habitat. WDFW is in the process of correcting fish passage problems at the location of the Dungeness River structure, with plans to complete work in 2017. The current three structures used to withdraw water from the Dungeness River will be reduced to one structure, which will be passable to upstream and downstream migrating fish (WDFW 2013a). The water intakes at Dungeness River Hatchery and Hurd Creek Hatchery will be screened and made passable to fish consistent with NMFS's 2011 criteria by the summer of 2017. The Kendall Creek Hatchery screens have been identified for replacement but are a lower priority than at other hatcheries, as listed fish do not utilize habitat upstream of the rack on Kendall Creek (WDFW 2014b). The Whitehorse Ponds Hatchery screen has not been identified for replacement. However, listed fish do not utilize habitat upstream of the water intake structure (WDFW 2014c).

Table 9. Compliance of instream structures at hatchery facilities used for five Puget Sound early winter steelhead hatchery programs with NMFS's screening and fish passage criteria.

	Criteria				
Facility	**Do Water Intake Screens Meet NMFS' Current Screening Criteria? (NMFS 2011a)**	**Do Water Intake Screens Meet Older NMFS' Screening Criteria?**	**Does the Hatchery Facility Operate Any Weirs?**	**Are Weirs Compliant with NMFS' Current Fish passage Criteria? (NMFS 2011a)**	**Are All Water Intake Structures Compliant With NMFS' Fish Passage Criteria? (NMFS 2011a)**
Dungeness River Hatchery	Yes	~~No~~Yes	Yes	Yes	No
Hurd Creek Hatchery	No	Yes	No	N/A	No
Kendall Creek Hatchery	No	Yes	Yes	Yes	No
McKinnon Pond	Yes	Yes	No	N/A	Yes
Whitehorse Ponds Hatchery	No	Yes	Yes	Yes	No
Wallace River Hatchery	No	Yes	Yes	No	No
Reiter Ponds	No	Yes	No	NA	NA
Tokul Creek Hatchery	Yes	Yes	Yes	No	No

Sources: WDFW 2013a; WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e.

A retrofitted intake at the Wallace River Hatchery has been identified as a high priority and design funds have been secured, but project completion depends on the availability of capital funds (WDFW 2014d). Listed species are not associated with the two water supply streams at Reiter Ponds, so the intake structures do not pose a risk to listed species. The water intake at the Tokul Creek Hatchery poses an upstream migration barrier and does not meet NMFS's 2011 fish passage criteria. Specific passage improvements in Tokul Creek are aimed at improving passage for adult Chinook salmon above the diversion dam into about 0.55 mile of potential habitat, and to improve fish screening at the water intake. Fish passage improvements are currently in the permitting phase (WDFW 2014e). The U.S. Army Corps of Engineers is the lead agency responsible for NEPA analyses of the potential improvements under the Clean Water Act.

The early winter steelhead and salmon hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins use several weirs to collect broodstock and/or manage adult returns. With the exception of the Tokul Creek Hatchery, all weirs are compliant with NMFS's 2011 criteria for fish passage (Table 9). ~~A weir is a barrier~~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

By blocking migration and concentrating salmon and steelhead into a confined area, weirs may also increase predation efficiency of mammalian predators (RIST 2009). The following summarizes the use of weirs at hatchery facilities that rear early winter steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins.

Dungeness River Hatchery: The weir and trap used to collect early winter steelhead as broodstock for the Dungeness River Hatchery program does not present any biological risks to natural fish populations. Steelhead broodstock are collected as volunteers to Dungeness River Hatchery. The facility is located away from listed natural-origin salmon and steelhead migration and rearing areas.

Hurd Creek Hatchery: No weir operates in conjunction with the early winter steelhead program.

Kendall Creek Hatchery: The weirs and trap for adult steelhead broodstock collection at Kendall Creek Hatchery do not affect migration or spatial distribution of natural-origin juvenile and adult Chinook salmon, steelhead, fall chum salmon, and pink salmon because the weirs are removed from migration and rearing areas for these fish species. Natural-origin coho salmon and sea-run cutthroat trout are encountered at the Kendall Creek weirs. Measures are applied to ensure that any coho salmon and cutthroat trout reaching the first weir and entering the adult collection pond are passed upstream above the second weir without delay to allow the fish to spawn naturally. Due to large picket spacing that allows unimpeded passage for juvenile fish, the Kendall Creek Hatchery weirs pose no risks to downstream migrating juvenile coho salmon or cutthroat trout.

McKinnon Pond: No weir operates in conjunction with the early winter steelhead program.

Whitehorse Ponds Hatchery: The weir for adult steelhead broodstock collection at Whitehorse Ponds Hatchery does not affect any natural-origin juvenile and adult salmon and steelhead because it is located in a small, off-channel creek, which is located away from natural-origin salmon and steelhead migration and rearing areas.

Wallace River Hatchery: The Wallace River Hatchery uses two water intakes, one in May Creek and another on the Wallace River. An instream trap is located in May Creek, and a weir placed across the Wallace River in early June each year, are used to obtain early winter steelhead broodstock. The weir in the Wallace River is removed around October 1 each year. Chinook salmon are not passed above the May Creek weir, but they are passed above the Wallace River intake and weir.

Reiter Ponds: No weir operates in conjunction with the early winter steelhead program.

Tokul Creek Hatchery: No weirs are operated in conjunction with the Tokul Creek Hatchery. A trap is used to collect early winter hatchery-origin steelhead broodstock that volunteer to the Tokul Creek Hatchery and does not present any biological risks to natural fish populations.

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, but maintenance activities are usually small in scale and duration, and return conditions to what they were when structures were first constructed.

3.2.3.4 Masking

As described in Subsection 3.2.3.1, Genetic Risks, although there is some overlap in spawn timing, the spawning time of early winter hatchery-origin steelhead substantially precedes the spawning time of natural-origin winter steelhead (Myers et al. 2015). Historically, it is believed that natural-origin early returning and later returning steelhead spawned in Puget Sound river basins, but the natural-origin early returning component is minimally present currently. Return timing is an aspect of the life history diversity within species that can be important for the long term adaptability and survival in a changing environment (e.g., McElhany et al. 2000; Moore et al. 2014). Spawn timing is another important factor that is related to the overlap between hatchery-origin and natural origin spawners. ~~However, in a~~ In ~~a~~ recent unpublished reports on fish spawning in Skagit River tributaries, McMillan (2015a, 2015b) suggests that overlap may be greater than indicated by the literature. ~~However, for the purposes of this analysis~~NMFS carefully reviewed that work and concluded that, due to the separation in spawning timing, ~~NMFS concludes that~~ the negative effect of early winter hatchery-origin steelhead on determining the status of natural-origin steelhead is negligible. The conclusions in McMillan (2015a, 2015b) are based on (1) extrapolations from observations of very limited numbers of fish (e.g., only six natural-origin steelhead during the entire 5-year survey period, with only one unmarked steelhead prior to March), (2) results that are not likely representative of the entire steelhead population, (3) likely errors in redd assignments to species (likely coho salmon and not steelhead), (4) available information from WDFW surveys in the Skagit River basin, and (5) the overlap analysis of Hoffman (2014).

3.2.3.5 Incidental Fishing Effects

Fisheries (recreational and tribal) targeting hatchery-origin fish may have incidental impacts on natural-origin fish. As described further below, this is because the fisheries targeting hatchery-origin steelhead occur when early returning natural-origin winter steelhead or other salmon species may be present. Information on the risks to natural-origin fish from harvest can be found in Subsection 2.1.5, Harvest Management, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a).

Implementation of mark-selective fishing rules for steelhead began in Puget Sound in the 1990s. Under selective fishing rules, anglers have only been able to retain steelhead with a clipped adipose fin. One hundred percent of the early winter hatchery-origin steelhead are mass-marked by having their adipose fins removed prior to their release (adipose clipped). This allows for identification of hatchery-origin fish during the fishery and prompt return of natural-origin fish to the water. Due to use of non-selective gear types (e.g., nets), tribal fisheries have less flexibility than recreational fisheries with respect to minimizing impacts on early returning natural-origin winter steelhead. The fisheries targeting early winter hatchery-origin steelhead generally start in November and end by late February. Cool water temperatures during those months minimize incidental mortality on listed (early returning) natural-origin steelhead that are caught and released[8]. In addition, because the steelhead fisheries targeting early winter hatchery-

[8] Direct studies on hook and releases mortality of steelhead have not been done in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River Basins. Nelson et al. (2005) showed catch and release mortalities of 1.4 percent to 5.8 percent in 1999 and 2000 respectively on steelhead caught in recreational fisheries on the Chilliwack River in British Columbia.

origin steelhead close before most of the natural-origin steelhead arrive, the number of natural-origin steelhead that are caught and released ~~would be~~ is low. As discussed in Subsection 3.2.3.4, Masking, there are differences of opinion regarding the extent to which early returning natural-origin fish overlap with hatchery-origin early winter steelhead. NMFS feels the overlap is negligible for the reasons discussed previously. ~~However, in recent unpublished reports describing fish spawning in Skagit River tributaries, McMillan (2015) suggests that overlap may be greater.~~ Because of their earlier freshwater migration timing, natural-origin summer steelhead in the Nooksack, Stillaguamish, and Snoqualmie/Tolt Rivers may be subject to catch and release effects to a greater extent than winter run steelhead[9]. Effects would remain low, however, because of the tendency for summer steelhead to migrate into and hold in upstream areas and tributaries of the watershed where they would be less susceptible to harvest in fisheries targeting early winter steelhead.

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 PS Harvest FEIS (NMFS 2004), which is a separate EIS analysis from the PS Hatcheries DEIS (2014a). The impacts are also evaluated in ESA section 7 biological opinions and 4(d) Rule evaluations (e.g., NMFS 2015a), specifically addressing the effects of the fisheries, as opposed to the hatchery programs. NMFS has determined that tribal and state harvest actions in Puget Sound in 2015 would not jeopardize the Puget Sound Steelhead DPS (NMFS 2015a). Because harvest impacts were previously evaluated in the PS Harvest FEIS (NMFS 2004), the effects of harvest on listed steelhead were not analyzed in further detail in the PS Hatcheries DEIS, or in this early winter steelhead EIS.

Prior to the 1990s, hatchery-origin steelhead were not mass-marked with an adipose clip. Therefore, anglers could not easily differentiate between natural-origin and hatchery-origin steelhead. During those

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This study also showed no indication of increased mortality on fish that had been caught and released multiple times. A hook-and-line mortality study conducted in the Samish River on winter-run steelhead also showed similar results, although it indicated that there may be a negative relationship between a fish being caught in a sport fishery and their survival to out-migration as kelts (Ashbrook et al. in press). Taylor and Barnhart (1999) determined that summer steelhead caught and released in the Mad and Trinity Rivers of California had a 9.5 percent mortality rate, with 83 percent of the mortalities occurring at water temperatures of 21°C or greater. Based on best available information, hooking mortality associated with recreational harvest is generally believed to be less than 10 percent of fish hooked and released.

[9] Adults from extant populations of winter steelhead return from December to May, and peak spawning occurs in March through May. Summer steelhead adults return from May through October and peak spawning occurs the following January to May (Hard et al. 2007).

years, recreational and tribal fisheriesFish managers tried to minimize harvest impacts on natural-origin winter-run steelhead by closing the managing fisheries that targeted earlier arriving hatchery-origin steelhead before the natural-origin winter-run populations arrived. However, fishermen may have inadvertently harvested the earliest-returning natural-origin steelhead, which may have changed the overall run timing of the population (i.e., evidence suggests that, historically, the natural-origin winter-run steelhead population had a larger proportion of adult fish returning prior to February [Myers et al. 2015]; see also McMillan 2015).

Where the status of a natural-origin salmon or steelhead population is healthy enough, catch and release or harvest fishing opportunities for those natural-origin fish may be developed and approved even for natural-origin populations that are listed as threatened under the ESA. For example, such recreational fisheries have been approved for listed natural-origin coho salmon (NMFS 2009). However, no such circumstances or targeted fisheries currently exist for natural-origin steelhead in Puget Sound, although some interests promote that approach in some cases (e.g., catch and release fishing for natural-origin Skagit River steelhead). Although fisheries managers may consider harvest opportunities for natural-origin steelhead, alternative fishery management scenarios for Puget Sound steelhead are beyond the scope of this EIS and are not analyzed.

3.2.3.6 Risk of Disease Transfer

Interactions between hatchery-origin fish and natural-origin fish in the environment may result in the transmission of pathogens if either the hatchery-origin or the natural-origin fish are harboring fish disease (Table 10). 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 pathogen (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 populations.

Table 10. Common fish pathogens found in hatchery facilities.

Pathogen	Disease	Species Affected
Renibacterium salmoninarum	Bacterial Kidney Disease (BKD)	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
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.

WDFW's hatchery facilities are operated in compliance with all applicable fish health guidelines (Pacific Northwest Fish Health Protection Committee 1989; IHOT 1995; WDFW and WWTIT 1998, updated 2006). These fish health guidelines ensure that fish health is monitored, sanitation practices are applied, and hatchery-origin fish are reared and released in healthy conditions. Pathologists from WDFW's Fish Health Section monitor hatchery programs monthly (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e). Exams performed at each life stage may include tests for virus, bacteria, parasites, or pathological changes.

3.2.3.7 Risk of "Mining" Natural-origin ~~Salmon and~~ Steelhead

Incorporating natural-origin fish into a hatchery broodstock can reduce the abundance and spatial structure of the natural-origin population, which is commonly referred to as "mining." Under existing conditions, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, there is no risk of "mining," because the programs do not "mine" the natural-origin populations by incorporating natural-origin fish into their broodstock (Table 11). This risk only applies to hatchery programs that use natural-origin fish for broodstock.

Table 11. Broodstock needs and natural-origin abundance information for five early winter steelhead hatchery programs Puget Sound.

River Basin of Hatchery Program	Broodstock Needs	Percentage of Natural-origin Steelhead in Broodstock (%)	Percentage of Hatchery-origin Steelhead in Broodstock (%)	Average Abundance of Natural-origin Winter Steelhead Population	TRT Interim Viable Abundance Target
Dungeness	Up to 30 with a 1:1 sex ratio	0	100	~~487[a]~~530[a]	1,232
Nooksack	Up to 100 with a 1:1 sex ratio	0	100	1,760[b]	11,023
Stillaguamish	Up to 120 with a 1:1 sex ratio	0	100	1,852[c]	9,559
Skykomish	Up to 300 with a 1:1 sex ratio	0	100	1,683[d]	10,695
Snoqualmie	Up to 100 with a 1:1 sex ratio	0	100	955[d]	8,370

Sources: WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e; Hard et al. (2015).
[a]Abundance based on average abundance in 2011, ~~and~~ 2013, and 2015. Surveys in 2010, and particularly in 2012, were cut short due to high water levels associated with spring rain and snow runoff; however escapement estimates can be obtained through the use of timing curves from other comparable river systems. The Jamestown S'Klallam Tribe has completed estimates of spawners for the entire season for 2011 and 2013. An estimated 410 fish spawned in 2011, ~~and~~ an estimated 564 fish spawned in 2013 after March 10; and 615 fish spawned in 2015. Prior to 2010, the last escapement estimate for Dungeness winter steelhead was in the 2000/2001 season with an estimated escapement of 183 based on index areas.
[b] Average escapement 2004 through 2012.
[c] Average abundance 2001 through 2012.
[d] Average abundance 2001 through 2013.

3.2.3.8 Population Viability Benefits

Some salmon and steelhead hatchery programs can contribute to the viability of natural-origin populations in terms of their abundance, spatial structure, diversity, and productivity. 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, Genetic Risks; and Subsection 3.2.3.2, Competition and Predation). There are two basic types of hatchery programs (integrated or isolated). Hatchery programs that (1) are reproductively connected (i.e., integrated) with a natural-origin population (if one still exists), (2) promote natural selection over hatchery selection, and (3) contain genetic resources that represent the ecological and genetic diversity of a species, are then included in an ESU or DPS. Only integrated hatchery programs can benefit viability; isolated programs do not benefit viability and may present risks to viability. 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).

3.2.3.9 Nutrient Cycling

Hatchery-origin adults that return and spawn naturally can contribute to the amount of marine derived nutrients in freshwater systems. For a review of marine-derived nutrients contributed by salmon and steelhead Puget Sound watersheds, see Subsection 3.2.3.7, Benefits – Marine-derived Nutrients, in the PS Hatcheries DEIS NMFS (2014a). Compared to other species, the contribution of hatchery-origin steelhead to marine-derived nutrients is negligible, and will not be considered further in this EIS. Information on the marine-derived nutrient benefits of hatchery programs on natural-origin salmon and steelhead can be found in Subsection 2.2.3, Benefits – Marine-derived Nutrients, in Appendix B, Hatchery Effects and Methods, in the PS Hatcheries DEIS (NMFS 2014a).

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 steelhead release numbers and hatchery program type may affect other fish species. Additional information on other fish species 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).

Many fish species other than salmon and steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins and other adjacent nearshore marine areas have a relationship with steelhead as prey, predators, or competitors (Table 12). 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 Puget Sound (Subsection 1.4, Project and Analysis Areas).

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 the species will not be considered further in the 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 12). Pacific herring (a forage fish for salmon and steelhead) is a Federal species of concern and a State candidate species. All of these species have a range that includes the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins or nearby marine areas. However, none of these species is located exclusively in these areas, and these areas are 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 early winter steelhead hatchery programs will not be considered further in the EIS.

Table 12. Range and status of other fish species that may be affected by five early winter steelhead hatchery programs in Puget Sound.

Species	Federal/State Listing Status	Type of Interaction with Salmon and Steelhead[1]
Bull trout	Federally listed as threatened	• Freshwater predator on salmon and steelhead eggs and juveniles • May compete with salmon and steelhead for food • May benefit from additional marine-derived nutrients
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
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 brook lamprey	Not listed. Pacific 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

Table 12. Range and status of other fish species that may be affected by five early winter steelhead hatchery programs in Puget Sound. (continued)

Species	Federal/State Listing Status	Type of Interaction with Salmon and Steelhead[1]
Margined sculpin	WDFW species of concern	• 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
Mountain sucker	Not federally listed, Washington State species of concern	• 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
Rockfish	Several species are federally listed as threatened and/or have State Candidate listing status[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 federal species of concern and a Washington State candidate species	• Prey for juvenile and adult salmon and steelhead • May compete with salmon and steelhead for food

Sources: Finger 1982; Horner 1978; Krohn 1968; Maret et al 1997; Polacek et al 2006; WDFW 2013b; Beamish 1980.

[1] Data on interactions specifically between other fish species and hatchery-origin 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 with hatchery-origin early winter steelhead are assumed to be similar to interactions between other fish and natural-origin steelhead.

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

In addition to Chinook salmon and steelhead, bull trout in the project area are also listed as a threatened fish species under the ESA. Bull trout in the five river basins are comprised of populations that are included as part of the "core areas" for the listed Puget Sound/Washington Coastal bull trout DPS: Dungeness River, Snohomish/Skykomish River, Stillaguamish River, and Nooksack River (USFWS 2004).

Under existing conditions, bull trout may be affected by the early winter steelhead hatchery programs primarily through facility operations (water intakes) (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]). Adverse effects on the listed Puget Sound/Washington Coastal bull trout DPS or its four component populations in the analysis area are negligible to low under existing conditions, for the following reasons: (1) bull trout would largely benefit from hatchery-origin steelhead releases because they may eat juvenile steelhead; (2) few bull trout would be expected to be intercepted at hatchery weirs and during in-river broodstock collection activities because primary spawning and rearing habitat for bull trout is well away from hatchery operations; and (3) bull trout in some areas (e.g., Snohomish River basin) are lake dwellers.

Overall, as described in other environmental analyses of Puget Sound hatchery programs (e.g,, Subsection 3.2, Fish, in the PS Hatcheries DEIS [NMFS 2014a]; and Dungeness Hatcheries DEA [NMFS 2015b]), under existing conditions the effects of steelhead on other fish species (freshwater species, including bull trout) in the analysis area are considered low or negligible.

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 that may be affected by the alternatives (Subsection 3, Affected Environment [introduction]), specifically, how changes in steelhead release numbers and hatchery program type may affect this species. Additional information on other wildlife species in the analysis area and effects associated with Puget Sound hatchery programs can be found in Subsection 3.5, Wildlife, in the PS Hatcheries DEIS (NMFS 2014a), which reviewed extensive information on other wildlife species in the analysis area and effects associated with Puget Sound hatchery programs and found that effects on most wildlife species were not substantial.

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 steelhead in the river basins associated with the early winter steelhead hatchery operations may, therefore, affect the viability of wildlife species that prey on these 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 at hatchery facilities).

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 steelhead as described in Subsection 3.5, Wildlife, in the PS Hatcheries DEIS (NMFS 2014a). The PS Hatcheries DEIS (NMFS 2014a) found that 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.

Six wildlife species occur in the analysis area that are federally listed as endangered or threatened under the ESA. Four of the species (spotted owl, Canada lynx, grizzly bear, and humpback whale) have little to no relationship with salmon and steelhead in the wildlife analysis area, or with salmon and steelhead hatcheries and for whom impacts associated with the alternatives would be negligible (Subsection 3.5.3.1, ESA-listed Species, in the PS Hatcheries DEIS [NMFS 2014a]). Of the remaining listed species (Southern Resident killer whale and marbled murrelet), effects of salmon and steelhead hatchery programs would be expected to be negligible. However, although effects on Southern Resident killer whales are expected to be negligible (Subsection 3.5, Wildlife, in the PS Hatcheries DEIS [NMFS 2014a]) in the wildlife analysis area and, 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. 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 Chinook salmon (e.g., Ford et al. 2016), even when other salmon species are more abundant. Chum salmon are more important in their diet in inland waters in the fall. There is no evidence that Southern Resident killer whales distinguish between hatchery-origin and natural-origin salmon. Adults from hatchery releases have partially compensated for declines in natural-origin salmon and may have benefited Southern Resident killer whales.

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. Early winter steelhead likely have a negligible positive effect on the diet of Southern Resident killer whales under existing conditions because early winter hatchery-origin steelhead comprise a very small part of the food base provided by total number of juvenile and adult hatchery-origin and natural-origin salmon (especially Chinook salmon) and steelhead available from throughout the greater Puget Sound, the Strait of Georgia, and Pacific Coast area (Subsection 3.5.3.1.1, Killer Whale, in the PS Hatcheries DEIS [NMFS 2014a]).

3.5 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, hatchery programs directly affect socioeconomic conditions in regions where the hatchery facilities operate. Hatchery facilities generate economic activity (personal income and jobs) by providing employment opportunities and through local procurement of goods and services for hatchery operations (e.g., fish food). Described in this subsection are socioeconomic conditions associated with early winter steelhead hatchery programs located in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins (Table 1), including hatchery employment, program costs and expenditures; regional economic values associated with recreational fisheries supported by the hatchery programs (determined by angling effort and harvest); and communities affected by hatchery operations and steelhead fisheries.

Recreational fishing for steelhead in the State of Washington is very popular. Since the early 1990s, recreational harvest of steelhead in Puget Sound rivers has been confined to hatchery-origin steelhead, resulting from the implementation of conservation measures to protect natural-origin steelhead by allowing retention of only hatchery-origin steelhead. As described in Subsection 3.3.2.6, Steelhead Fisheries, in the PS Hatcheries DEIS (NMFS 2014a), steelhead fisheries in Puget Sound target hatchery production, which includes ~~(primarily~~ early winter steelhead~~)~~, ~~with the exception of hatchery-origin summer-run steelhead~~ and, in the Stillaguamish River and Snohomish River systems, also includes hatchery-origin summer run steelhead. As described in Subsection 3.2.3.5, Incidental Fishing Effects, the run timing of early winter hatchery-origin steelhead tends to be earlier than natural-origin winter steelhead, enabling fisheries to target hatchery-origin fish with low incidental mortality to natural-origin winter steelhead. Recreational fishing for steelhead also involves anglers that prefer to catch and release

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fish, rather than to retain them, but estimates of the level of this activity are not available for Puget Sound, and would not be expected to change under the alternatives.

The analysis area for socioeconomics includes the geographic area where the Proposed Action would occur (Subsection 1.4, Project and Analysis Areas), and includes Clallam, Whatcom, Snohomish, and King Counties. These are the counties containing the communities that are primarily affected by fisheries targeting early winter steelhead produced in the five hatchery programs. Additional information on the socioeconomic methods can be found in Appendix C, Socioeconomics Methods.

3.5.1 Hatchery Operations

The contribution of the five hatchery programs to local and regional economies includes direct employment, operation and maintenance costs, and direct hatchery expenditures. The total number of full-time equivalent (FTE) jobs associated with the eight hatchery facilities used to support the five early winter steelhead programs is 19.3 (WDFW 2014a; WDFW 2014b; WDFW 2014c;WDFW 2014d; WDFW 2014e). The number of FTEs associated with the five early winter steelhead programs by hatchery facility is:

Dungeness River Program

- Dungeness River Hatchery: 3.0 FTEs
- Hurd Creek Hatchery: 2.5 FTEs

Kendall Creek Program

- Kendall Creek Hatchery and McKinnon Pond: 4.3 FTEs

Whitehorse Ponds Program

- Whitehorse Ponds: 2.1 FTEs

Snohomish/Skykomish Program

- Wallace Hatchery: 3.5 FTEs
- Reiter Ponds: 1.5 FTEs

Tokul Creek Program

- Tokul Creek Hatchery: 2.4 FTEs

Annual operations and maintenance expenditures for the eight facilities are estimated to cost a total of $2.02 million (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e). These expenditures provide economic benefits to local economies, particularly small communities with commercial businesses in close proximity to the hatcheries. The economies of the following small communities in the analysis area are believed to be particularly affected by early winter steelhead hatchery operations in each basin:

- Dungeness River basin: Sequim (Clallam County)
- Nooksack River basin: Bellingham and Ferndale (Whatcom County)
- Stillaguamish River basin: Stanwood, Arlington, and Darrington (Snohomish County)
- Snohomish/Skykomish River basin: Snohomish, Monroe, and Sultan (Snohomish County)
- Snoqualmie River basin: Monroe, Duvall, Carnation, and Fall City (King County)

Direct hatchery-related expenditures for labor and procurement of supplies also generate economic activity, both locally (near where the hatcheries operate) and in more distant areas where more goods and services are available. Personal income directly and indirectly attributable to hatchery operations at the eight hatchery facilities currently totals about $1.77 million annually. Of this total personal income, early winter steelhead hatchery programs account for $496,000, or 28 percent of the total, representing a low positive impact in the analysis area. This personal income not only affects the communities identified above, but other communities in the analysis area as well.

The expenditures to produce hatchery-origin juveniles that are released from early winter steelhead hatchery programs account for the costs of production, but do not describe the extent to which fish from each program contribute as fish that return as adults for harvest purposes. Producing fish that contribute to harvest is the goal of the five early winter steelhead hatchery programs (Subsection 3.2.2.4, Background on Existing Early Winter Steelhead Hatchery Programs). Survival of juveniles to the adult return stage may vary for each program. Based on the numbers of hatchery-origin adults that return from the five hatchery programs, WDFW (2009) estimated the cost of each adult fish to be $84 per fish for the Dungeness program (releases from Dungeness Hatchery and Hurd Creek Hatchery), $286 per fish for the Nooksack program (releases from Kendall Creek Hatchery), $92 per fish for the Stillaguamish program (releases from Whitehorse Ponds Hatchery), $40 per fish for the Skykomish program (releases from Wallace River Hatchery), $18 per fish for releases from Reiter Ponds, and $53 per fish for the Snoqualmie program (releases from Tokul Creek Hatchery). However, because these costs per adult values would be the same under the alternatives, this information is not analyzed further in the EIS.

3.5.2 Fisheries

In addition to the economic benefits of hatchery operations to local and regional economies, steelhead produced from the five early winter steelhead hatchery programs contribute to recreational, and tribal commercial and ceremonial and subsistence fisheries in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. The Skykomish River and Snoqualmie River are major tributaries in the Snohomish River basin, and releases of early winter hatchery-origin steelhead from the hatchery programs in the Skykomish and Snoqualmie River basins also contribute to harvest and related benefits of downstream fisheries in the Snohomish River. In total, hatchery programs in the five river basins produce about 50 percent of the hatchery-origin winter and summer steelhead released into Puget Sound rivers annually for the purposes of augmenting fisheries harvests[10], including recreational fisheries and tribal commercial and ceremonial and subsistence fisheries. There is no non-tribal commercial harvest of steelhead.

Based on estimates of harvest from the 2004 to 2005 through 2013 to 2014 steelhead fishing seasons from the WDFW Sport Catch Reports (Appendix C, Socioeconomics Methods), production of early winter steelhead from the five programs is estimated to support, on average, an annual recreational harvest of 4,412 adult hatchery-origin fish. Of this total, average harvest includes 42 fish in the Dungeness River basin, 143 fish in the Nooksack River basin, 404 fish in the Stillaguamish River basin, 2,226 fish in the Skykomish River basin, and 1,597 fish in the Snoqualmie River basin (Appendix C, Socioeconomics Methods). As indicated above, early winter steelhead hatchery production also supports limited tribal fisheries, providing a small number of steelhead for commercial and ceremonial and subsistence harvests. Tribes that benefit from this production include the Lummi Nation, Nooksack Tribe, Stillaguamish Tribe of Indians ~~Tribe~~, Tulalip Tribes, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Lower Elwha Klallam Tribe.

Fisheries supported by the five hatchery programs contribute to local economies through the purchase of goods and supplies associated with fishing, and by the retention of local services such as outfitter and guiding services. For example, supplies needed for fishing include fishing gear and camping equipment; the purchase of travel-related goods and services includes food and drinks, fuel, and miscellaneous retail goods at local businesses. Angler expenditures on fishing-related goods and services would be expected to contribute to both local and non-local businesses (from expenditures by out-of-area visitors); however,

[10] The early winter steelhead programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins produce up to 620,000 fish annually for harvest augmentation purposes. The total number of steelhead released for harvest augmentation purposes in all Puget Sound tributaries is about 1,243,000 (including early winter steelhead, summer steelhead, and integrated winter steelhead) (Appendix A, Puget Sound Salmon and Steelhead Hatchery Programs and Facilities).

it is uncertain how dependent these businesses are on fishing-related expenditures, specifically those related to steelhead fishing.

Recreational fishing effort for early winter hatchery-origin steelhead in the five river basins is estimated at about 78,400 angler trips. This estimate is based on an average catch per unit of effort of 17.77 trips per fish caught (Appendix C, Socioeconomics Methods). Based on an average regional economic impact factor of $67.30 per angler trip, current production from early winter steelhead hatchery programs is estimated to generate about $5.3 million annually in regional economic income.

Salmon (and steelhead) fishing has been a focus for tribal economies, cultures, lifestyles, and identities for ~~over 1,000 years~~ many millennia (Gunther 1950~~; Stein 2000~~). Beyond generating jobs and income for contemporary commercial tribal fishers, salmon and steelhead are regularly eaten by individuals and families, and are served at gatherings of elders at traditional dinners and other ceremonies. To Native American tribes, salmon and steelhead are a core symbol of tribal and individual identity (Stay 2012; NWIFC 2013). The survival and well-being of salmon and steelhead are seen as extricable linked to the survival and well-being of Indian people and their cultures (Meyer Resources Inc. 1999). Salmon and steelhead evoke sharing, gifts from nature, responsibility to the resource, and connection to land and water.

Puget Sound treaty tribes use salmon and steelhead in various ways, including personal and family consumption, informal and formal distribution and community sharing, and ceremonial uses (Amoss 1987). As noted in the PS Hatcheries DEIS (NMFS 2014a) tribal commercial incidental steelhead harvest averaged 604 fish from 2002 to 2006 (range 260 to 787 fish). Most tribal steelhead fisheries occur in freshwater areas. Tribal fishers also harvest some steelhead in commercial, ceremonial, and subsistence fisheries (primarily using set nets). Therefore, for the purposes of this analysis, early winter steelhead hatchery programs are assumed to have a moderate positive effect on affected tribes.

Overall, considering the socioeconomic values from hatchery operations and fishing activities associated with the five early winter steelhead hatchery programs, for the purposes of this analysis NMFS concludes the hatchery programs have a moderate positive effect on socioeconomic conditions in the analysis area. This is because the five early winter steelhead hatchery programs support an estimated 78,400 angler trips and are estimated to generate a total $5.8 million ($496,000 in income from hatchery operations, and $5.3 million from recreational fishing) to persons and businesses in the analysis area annually. Most of the personal income benefits would be expected to occur in or near the 13 communities within the four counties identified in Subsection 3.5.1, Hatchery Operations, where most of the affected fisheries occur and where the hatchery facilities are located. The positive effects of angler spending and hatchery operations occur throughout Clallam, Whatcom, Snohomish, and King Counties where the hatchery facilities and fisheries are located, but are likely most substantial in Snohomish County where 41 percent of the production of early winter steelhead occurs (a total of 256,000 of 620,000 fish produced at Wallace Hatchery and Reiter Ponds).

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* (EO 12898), 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 EO 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[11]
- 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 the Council on Environmental Quality's (CEQ's) *Environmental Justice Guidance under the National Environmental Policy Act* of December 10, 1997. CEQ's *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

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

general population or other 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 guidelines do 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 is the same as for socioeconomics and includes the geographic area where the Proposed Action would occur (Subsection 1.4, Project and Analysis Areas), including the geographic areas of Clallam, Whatcom, Snohomish, and King Counties. The early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins raise and release fish in Clallam, Whatcom, Snohomish, and King Counties. These are also the counties that are primarily affected by fisheries targeting early winter steelhead produced in these hatchery programs.

Clallam and Whatcom Counties are environmental justice communities of concern because 5.5 percent of the population of Clallam County and 3.1 percent of the population of Whatcom County is American Indian/Alaskan Native compared to 1.8 percent for the state as a whole (Table 13). In addition, the per capita income is $25,865 for Clallam County and $26,530 for Whatcom County, which is meaningfully less than the per capita income of $30,742 for the state as a whole (Table 13). Whatcom County's poverty level (16.4 percent of the population) also meaningfully exceeds the poverty level of the state as a whole (13.4 percent of the population) (Table 13).

Table 13. Population size, percent minority, per capita income, and percent below poverty level in Clallam, Whatcom, Snohomish, and King Counties and Washington State.

Indicator	Clallam County	Whatcom County	Snohomish County	King County	Washington State
Population (2013)	72,350	205,800	730,500	1,981,900	6,882,400
Percent Black (%)	0.9	1.1	2.7	6.5	3.8
Percent American Indian/Alaskan Native (%)	5.5	3.1	1.6	1.0	1.8
Percent Asian and Pacific Islanders (%)	1.6	4.0	9.7	15.9	8.1
Percent Hispanic (%)	5.3	8.2	9.3	9.4	11.7
Per Capita Income ($)	25,865	26,530	31,349	39,911	30,742
Percent of persons below poverty level, 2009-2013 (%)	14.6	16.4	10.4	11.5	13.4

Shading of cells represents values that meaningfully exceeded (by 10 percent or greater) those of the reference population (Washington State), making them environmental justice communities of concern.
Sources: Population statistics: 2013 Washington State Data Book. Washington Office of Financial Management. 2014. Available at : http://www.ofm.wa.gov/localdata/default.asp
Economic statistics: U.S. Bureau of Census. 2013. State/County QuickFacts. Available at: http://quickfacts.census.gov/qfd/states/53/53009.html
Both accessed July 29, 2015

Based on per capita income and poverty level, Snohomish County and King County are not environmental justice communities of concern (Table 13). However, the percentage of the King County population that is Black (6.5 percent of the population), and the percentages of the King County and Snohomish County populations that are Asian and Pacific Islander are meaningfully greater than the state as a whole (3.8 percent and 8.1 percent, respectively), so Snohomish County and King County can also be considered environmental justice communities of concern.

All counties in the analysis area are similarly affected by the early winter steelhead hatchery programs and fishing opportunities they present as described in Subsection 3.5, Socioeconomics, and early winter steelhead hatchery programs result in low positive environmental justice impacts. The most substantial impacts occur in Clallam County and Whatcom County because per capita income and the percentage of persons below the poverty level are the highest.

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 the Environmental Justice Executive Order, the presidential directive on government-to-government relations, and the trust responsibility to Indian tribes 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 on the natural or physical environment (EPA 1998).

As described in Subsection 3.5 (Socioeconomics), salmon fishing has been a focus for tribal economies, cultures, lifestyles, and identities for ~~over 1,000 years~~many millennia (Gunther 1950). These activities continue to be important today, both economically and for subsistence and ceremonial purposes (Stay 2012; NWIFC 2013). Returning early winter hatchery-origin steelhead adults provide for limited tribal commercial and subsistence use, affording moderate positive effects. The following tribes or their representatives work with WDFW to develop fishing plans that target early winter hatchery-origin steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins: Lummi Nation, Nooksack Tribe, Stillaguamish Tribe of Indians~~ Tribe~~, Tulalip Tribes, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Lower Elwha Klallam Tribe.

Chapter 4

4 ENVIRONMENTAL CONSEQUENCES

Chapter 4, Environmental Consequences, evaluates potential effects of the alternatives (including the Proposed Action) on the biological, physical, and human resources described in Chapter 3, Affected Environment. NMFS has defined the No-action Alternative as not making a determination under the 4(d) Rule, leading to termination of the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins (Subsection 2.2.1, Alternative 1). All of the hatchery facilities that support the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would continue to operate under Alternative 1 because they also raise fish for hatchery programs that are not part of the Proposed Action or its alternatives.

As discussed in Chapter 2, Alternatives Including the Proposed Action, the existing early winter steelhead hatchery programs would be terminated under Alternative 1 (No-action Alternative). The effects of Alternative 1 are described relative to the effects of existing winter steelhead hatchery programs that are ongoing within the project area, including release of smolts[1] (Chapter 3, Affected Environment). As described in the analyses below, program implementation under Alternative 2 would be similar to operations under existing conditions that are described in Chapter 3, Affected Environment. However, there are some difference between Alternative 2 and existing conditions (regarding recent past hatchery practices), this is addressed in the discussion of effects under Alternative 2.

The effects of Alternative 2 (Proposed Action) through ~~Alternative 4 (Native Broodstock)~~ Alternative 5 (Preferred Alternative) are described relative to Alternative 1 (No Action). In addition, the effects of

[1] As noted in Chapter 3, Affected Environment, WDFW did not release early winter steelhead hatchery-origin smolts in 2014 or 2015 consistent with the Consent Decree in *Wild Fish Conservancy v. Anderson* (W.D. Wash.). However, Chapter 3, Affected Environment, describes the full effects of the existing early winter steelhead hatchery programs including the effects of releases from those programs, because these are longstanding programs, and the effects of smolt releases on the environment have been present for decades.

Alternative 1 (No Action) through ~~Alternative 4~~ Alternative 5 are described relative to existing conditions, which would be similar to Alternative 2 (Proposed Action), except where specifically noted. The relative magnitude and direction of impacts is 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

Hatchery facility use of surface water and groundwater is both consumptive and non-consumptive as described in Subsection 3.1, 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 water source (the stream bypass reach) may be dewatered (has less water between the point of diversion and discharge return to the river). Effects to existing sources include alteration of stream flow and changes in water quantity (Subsection 3.1, Water Quantity).

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

Under Alternative 1, the early winter steelhead programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be terminated immediately (Subsection 2.2.1, Alternative 1). All of the hatchery facilities that support these hatchery programs would continue to operate since they support hatchery programs that are not part of the Proposed Action. ~~However,~~ Although the hatchery facilities would be raising 620,000 fewer early winter hatchery-origin steelhead~~.~~ ~~Therefore~~, ~~s~~short- and long-term water use would not be less under Alternative 1 than under existing conditions (Table 14), because the facilities would be used to rear other species. ~~Less water use would positively affect low flow conditions by decreasing the percent of hatchery program water withdrawals (Table 14), and positively affect ground water supplies where ground water is used, relative to existing conditions.~~ There would be no change in compliance with water permits or water rights at any of the hatchery facilities under Alternative 1 ~~because less water would be used at the hatchery facilities relative to existing conditions or the permits, or water rights would no longer be necessary or applicable~~ (Subsection 3.1, Water Quantity). Analyses of the site-specific effects of Alternative 1 is provided below.

Dungeness River Basin: The Dungeness River Hatchery uses surface water exclusively, withdrawn through three water intakes on the Dungeness River and one on Canyon Creek, an adjacent tributary. All water diverted from Dungeness River and Canyon Creek (minus evaporation) is returned after it circulates through the hatchery facility (Subsection 3.1, Water Quantity). Under existing conditions, the Dungeness River Hatchery uses approximately 2.0 cfs of surface water from the Dungeness River and 0.4 cfs of water from Canyon Creek to support the early winter steelhead program (Table 14). Water quantity is only affected between the water intake and discharge structures.

Under Alternative 1, surface water would not be temporarily diverted into the hatchery to support the early winter steelhead hatchery program, but would continue to be diverted and used to rear other species, which would result in a low negative ~~positive~~ effect on water quantity in the Dungeness River, and moderate negative ~~positive~~ effect on water quantity in Canyon Creek between the water intake and discharge structures, which is the same as under existing conditions (Table 14)~~because more water would remain in the Dungeness River and Canyon Creek relative to existing conditions (Table 14)~~.

The Hurd Creek Hatchery facility uses a combination of groundwater withdrawn from five wells and surface water withdrawn from Hurd Creek. All water diverted from Hurd Creek (minus evaporation) is returned to the creek after it circulates through the hatchery facility (Subsection 3.1, Water Quantity). Under existing conditions, the Hurd Creek Hatchery withdraws up to 0.26 cfs from Hurd Creek and 0.95 cfs from five wells to support the early winter steelhead program in the Dungeness River basin (Table 14). Water quantity is only affected between the water intake and discharge structures.

Under Alternative 1, 0.26 cfs of surface water would continue to ~~not~~ be temporarily diverted into the hatchery, but would be used to rear other species, which would result in a moderate negative~~positive~~ effect on water quantity in Hurd Creek between the water intake and discharge structures, the same as under existing conditions (Table 14)~~because more water would remain in Hurd Creek relative to existing conditions (Table 14)~~. Under Alternative 1, 0.95 cfs of groundwater would not be used to support the early winter steelhead hatchery program, but would continue to be used to rear other species, and may lead to a low negative~~positive~~ effect on groundwater supply, which is the same as under existing conditions~~because an additional 0.95 cfs of water would remain in the aquifer for other water users relative to existing conditions~~.

Table 14. Water diverted to support five early winter steelhead hatchery programs in Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River Basins.

Facility	Maximum Use of Water to Support Steelhead Programs Under Existing Conditions (cfs)	Maximum Percentage of Minimum Flows Diverted Under Existing Conditions (%)	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Native Broodstock)	Alternative 5 (Preferred Alternative)
Dungeness River Hatchery	Surface: 2.0 cfs from Dungeness River Surface: 0.4 cfs from Canyon Creek	3.6 of Dungeness River 20.0 from Canyon Creek	Surface: ~~0~~2.0 cfs from Dungeness River Surface: 0.4 cfs from Canyon Creek	Surface: 2.0 cfs from Dungeness River Surface: 0.4 cfs from Canyon Creek	Surface: 2~~1~~.0 cfs from Dungeness River Surface: 0.4~~2~~ cfs from Canyon Creek	Surface: 2.0 cfs from Dungeness River Surface: 0.4 cfs from Canyon Creek	Surface: 2.0 cfs from Dungeness River Surface: 0.4 cfs from Canyon Creek
Hurd Creek Hatchery	Surface: 0.26 cfs from Hurd Creek Ground: 0.95 cfs	13.0 from Hurd Creek	Surface: 0.26 cfs from Hurd Creek Ground: 0.95 cfs	Surface: 0.26 cfs from Hurd Creek Ground: 0.95 cfs	Surface: 0.26~~13~~ cfs from Hurd Creek Ground: 0.95~~48~~ cfs	Surface: 0.26 cfs from Hurd Creek Ground: 0.95 cfs	Surface: 0.26 cfs from Hurd Creek Ground: 0.95 cfs
Kendall Creek Hatchery	Surface: 6.7 cfs from Kendall Creek Ground: 7.7 cfs	1.3 from Kendall Creek	Surface: ~~0~~ 6.7 cfs from Kendall Creek Ground: ~~0~~7.7 cfs	Surface: 6.7 cfs from Kendall Creek Ground: 7.7 cfs	Surface:6.7 ~~3.4~~ cfs from Kendall Creek Ground: 7.7~~3.9~~ cfs	Surface: 6.7 cfs from Kendall Creek Ground: 7.7 cfs	Surface: 6.7 cfs from Kendall Creek Ground: 7.7 cfs
McKinnon Pond	Surface: 2.0 cfs from Peat Bog Creek	0.3 from Peat Bog Creek (note that steelhead are not reared in McKinnon Pond during low flow conditions so this is the proportion used during average flow conditions)	Surface: ~~0~~ 2.0 cfs from Peat Bog Creek	Surface: 2.0 cfs from Peat Bog Creek	Surface: 2~~1~~.0 cfs from Peat Bog Creek	Surface: 2.0 cfs from Peat Bog Creek	Surface: 2.0 cfs from Peat Bog Creek

Table 14. Water diverted to support five early winter steelhead hatchery programs in Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River Basins (continued).

Facility	Maximum Use of Water to Support Steelhead Programs Under Existing Conditions (cfs)	Maximum Percentage of Minimum Flows Diverted Under Existing Conditions (%)	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3 (Reduced Production)	Alternative 4 (Native Broodstock)	Alternative 5 (Preferred Alternative)
Whitehorse Ponds Hatchery	Surface: 2.4 cfs from Whitehorse Springs Creek Ground: 0.5 cfs	1.2 from Whitehorse Springs Creek	Surface: ~~0~~2.4 cfs from Whitehorse Springs Creek Ground: 0.5 cfs	Surface: 2.4 cfs from Whitehorse Springs Creek Ground: 0.5 cfs	Surface: ~~1.2~~ 2.4cfs from Whitehorse Springs Creek Ground: 0.5~~3~~ cfs	Surface: 2.4 cfs from Whitehorse Springs Creek Ground: 0.5 cfs	Surface: 2.4 cfs from Whitehorse Springs Creek Ground: 0.5 cfs
Wallace River Hatchery	Surface: 6.4 cfs from Wallace River Surface: 2.2 cfs from May Creek	2.1 from Wallace River 0.7 from May Creek	Surface: ~~0~~ 6.4 cfs from Wallace River Surface: ~~0~~2.2 cfs from May Creek	Surface: 6.4 cfs from Wallace River Surface: 2.2 cfs from May Creek	Surface: ~~3.2~~ 6.4 cfs from Wallace River Surface: ~~1.1~~ 2.2 cfs from May Creek	Surface: 6.4 cfs from Wallace River Surface: 2.2 cfs from May Creek	Surface: 6.4 cfs from Wallace River Surface: 2.2 cfs from May Creek
Reiter Ponds	Surface: 4.9 cfs from Austin Creek Surface: 4.9 cfs from Hogarty Creek	1.6 from Austin Creek 1.6 from Hogarty Creek	Surface: ~~0~~4.9 cfs from Austin Creek Surface: ~~0~~4.9 cfs from Hogarty Creek	Surface: 4.9 cfs from Austin Creek Surface: 4.9 cfs from Hogarty Creek	Surface: ~~2.5~~ 4.9 cfs from Austin Creek Surface: ~~2.5~~ 4.9 cfs from Hogarty Creek	Surface: 4.9 cfs from Austin Creek Surface: 4.9 cfs from Hogarty Creek	Surface: 4.9 cfs from Austin Creek Surface: 4.9 cfs from Hogarty Creek
Tokul Creek Hatchery	Surface: 5.4 cfs from Tokul Creek Surface: 2.7 cfs from unnamed spring	0.8 from Tokul Creek 0.9 from unnamed spring	Surface: ~~0~~5.4 cfs from Tokul Creek Surface: ~~0~~2.7 cfs from unnamed spring	Surface: 5.4 cfs from Tokul Creek Surface: 2.7 cfs from unnamed spring	Surface: ~~2.7~~ 5.4 cfs from Tokul Creek Surface: ~~1.4~~ 2.7 cfs from unnamed spring	Surface: 5.4 cfs from Tokul Creek Surface: 2.7 cfs from unnamed spring	Surface: 5.4 cfs from Tokul Creek Surface: 2.7 cfs from unnamed spring

Source: Existing conditions are found in Table 4.

Nooksack River Basin: The Kendall Creek Hatchery uses well and surface water (Subsection 3.1, Water Quantity). All water diverted from Kendall Creek (minus evaporation) is returned to the creek after it circulates through the hatchery facility (Subsection 3.1, Water Quantity). Under existing conditions, the Kendall Creek Hatchery uses approximately 6.7 cfs of surface water from Kendall Creek and 7.7 cfs of groundwater to support the early winter steelhead program (Table 14). Water quantity is only affected between the water intake and discharge structures.

Under Alternative 1, 6.7 cfs of water would continue to ~~not~~ be temporarily diverted from Kendall Creek into the hatchery, but would be used to support production of other species. This~~, which~~ would result in a negligible negative ~~positive~~ effect on water quantity between the water intake and discharge structures, which is the same as under existing conditions (Table 14)~~because more water would remain in Kendall Creek relative to existing conditions (Table 14)~~. Under Alternative 1, 7.7 cfs of groundwater would not be used to support the early winter steelhead hatchery program, but would continue to be used to rear other species, and may lead to a low negative ~~positive~~ effect on groundwater supply, which is the same as under existing conditions ~~because an additional 7.7 cfs of water would remain in the aquifer for other water users relative to existing conditions~~.

McKinnon Pond uses surface water exclusively (Subsection 3.1, Water Quality). All water diverted from Peat Bog Creek (minus evaporation) is returned after it circulates through the rearing pond (Subsection 3.1, Water Quantity). Under existing conditions, McKinnon Pond uses approximately 2.0 cfs of surface water from Peat Bog Creek from December through February (Table 14).

Under Alternative 1, this water would continue to ~~not~~ be temporarily diverted into the rearing pond, which would result in a negative ~~positive~~ negligible effect on water quantity in Peat Bog Creek between the water intake and discharge structures, which is the same as under existing conditions (Table 14)~~because more, but likely only a small amount more, water would remain in the Peat Bog Creek relative to existing conditions (Table 14)~~.

Stillaguamish River Basin: The Whitehorse Ponds Hatchery uses well and surface water (Subsection 3.1, Water Quantity). All water diverted from Whitehorse Springs Creek (minus evaporation) is returned to Whitehorse Springs Creek after it circulates through the hatchery facility (Subsection 3.1, Water Quantity). Under existing conditions, the Whitehorse Ponds Hatchery uses approximately 2.4 cfs of surface water from Whitehorse Ponds Creek and 0.5 cfs of groundwater to support their early winter steelhead program (Table 14). Under Alternative 1, 2.4 cfs of water would continue to ~~not~~ be temporarily diverted from Whitehorse Springs Creek into the hatchery, which would result in a negligible negative ~~positive~~ effect on water quantity in Whitehorse Springs Creek, which is the same as under existing conditions (Table 14) ~~because more, though likely just somewhat more, water would remain in Whitehorse Springs Creek relative to existing conditions (Table 14)~~. Under Alternative 1, 0.5 cfs of groundwater would not be used to support the early winter steelhead hatchery program, but would continue to be used to rear other species, and may lead to a low negative~~positive~~ effect on groundwater supply, which is the same as under existing conditions~~because an additional 0.5 cfs of water would remain in the aquifer for other water users relative to existing conditions~~.

Skykomish River Basin: The Wallace River Hatchery uses surface water exclusively (Subsection 3.1, Water Quantity). All water is returned to the Wallace River and May Creek (minus evaporation) after circulating through the facilities (Subsection 3.1, Water Quantity). Under existing conditions, the Wallace River Hatchery withdraws up to 6.4 cfs from Wallace River and up to 2.2 cfs from May Creek to support the early winter steelhead hatchery program (Table 14). Water quantity is only affected between the water intakes and discharge structures. Under Alternative 1, up to 6.4 cfs would not be withdrawn from the Wallace River and 2.2 cfs would not be withdrawn from May Creek to support the early winter steelhead hatchery programs, but would continue to be used to rear other species, which would lead to a negligible negative~~positive~~ effect, which is the same as under existing conditions ~~because more of the water would be left in the Wallace River and May Creek relative to existing conditions~~.

Under existing conditions, Reiter Ponds withdraws up to 4.9 cfs from Austin Creek and up to 4.9 cfs from Hogarty Creek (Subsection 3.1, Water Quantity). All water is returned to the creeks (minus evaporation) after circulating through the facilities. Under Alternative 1, 4.9 cfs would not be temporarily withdrawn from the Austin Creek or from Hogarty Creek to support the early winter steelhead hatchery programs, but would continue to be used to rear other species, which may lead to a negligible negative~~positive~~ effect, which is the same as under existing conditions~~because up to 4.9 cfs would be left in Austin Creek and in Hogarty Creek relative to existing conditions~~. Water quantity is only affected between the water intakes and discharge structures.

Snoqualmie River Basin: The Tokul Creek Hatchery uses surface water (Subsection 3.1, Water Quantity). The Tokul Creek Hatchery withdraws up to 5.4 cfs from Tokul Creek and up to 2.7 cfs from a spring to support the early winter steelhead hatchery program (Table 14). All water is returned to the creek after circulating through the hatchery. Water quantity is only affected between the water intake and discharge structures.

Under Alternative 1, up to 5.4 cfs of water would not be temporarily withdrawn from Tokul Creek and up to 2.7 cfs would not be withdrawn from the spring to support the early winter steelhead hatchery programs, but this amount of water would continue to be withdrawn for rearing other species, which may lead to a negligible negativepositive effect, which is the same as under existing conditionsbecause more of the water would be left in Tokul Creek and in the spring relative to existing conditions.

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 early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would operate as proposed in submitted HGMPs (Subsection 2.2.1, Alternative 2). As described above, WDFW has stated that if the early winter steelhead programs were discontinued, water use at the hatcheries would remain the same, because the water would be used to support production of other species. Consequently, short- and long-term water use and effects would be greater underthe same under Alternative 2 relative toas under Alternative 1 and the same as under existing conditions (Subsection 3.1, Water Quantity). More water use would negatively affect low flow conditions by increasing the percent of hatchery program water withdrawals (Table 14), and by decreasing ground water supplies where ground water is used, relative to Alternative 1. As under Alternative 1, there would be no change in compliance with water permits or water rights at any of the hatchery facilities under Alternative 2 because the hatchery programs have existing permits and water rights to divert water as proposed in the submitted HGMPs. Analyses of the site-specific effects of Alternative 2 are provided below.

Dungeness River Basin: The Dungeness River Hatchery uses surface water exclusively, withdrawn through three water intakes on the Dungeness River and one on Canyon Creek, an adjacent tributary. All water diverted from Dungeness River and Canyon Creek (minus evaporation) is returned after it circulates through the hatchery facility (Subsection 3.1, Water Quantity).

Under Alternative 2, the Dungeness River Hatchery would use approximately 2.0 cfs of surface water from the Dungeness River and 0.4 cfs of water from Canyon Creek to support their early winter steelhead program (Table 14). Alternative 2 would result in a moderate negative effect on water quantity in the Dungeness River and in Canyon Creek between the water intake and discharge structures relative to Alternative 1.

The Hurd Creek Hatchery facility uses a combination of groundwater withdrawn from five wells, and surface water withdrawn from Hurd Creek. All water diverted from Hurd Creek (minus evaporation) is returned after it circulates through the hatchery facility (Subsection 3.1, Water Quantity).

~~Under Alternative 2, the Hurd Creek Hatchery may withdraw up to 0.26 cfs from Hurd Creek to support the early winter steelhead program in the Dungeness River basin (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 2 would have a moderate negative effect on water quantity in Hurd Creek between the water intake and discharge structures relative to Alternative 1.~~

~~Under Alternative 2, the Hurd Creek Hatchery may withdraw up to 0.95 cfs from wells to support the early winter steelhead hatchery program relative to Alternative 1. This withdrawal may lead to a low negative effect on groundwater supply because 0.95 cfs of water would not remain in the aquifer for other water users in contrast to Alternative 1.~~

~~**Nooksack River Basin:** The Kendall Creek Hatchery uses well and surface water (Subsection 3.1, Water Quantity). All water diverted from Kendall Creek (minus evaporation) is returned to the creek after it circulates through the hatchery facility (Subsection 3.1, Water Quantity).~~

~~Under Alternative 2, the Kendall Creek Hatchery would use approximately 6.7 cfs of surface water from Kendall Creek to support the early winter steelhead program (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 2 would result in a low negative effect on water quantity in Kendall Creek relative to Alternative 1.~~

~~Under Alternative 2, 7.7 cfs of groundwater would be used to support the early winter steelhead hatchery program. Because this water would not be used under Alternative 1, Alternative 2 may lead to a low negative effect on groundwater supply relative to Alternative 1.~~

~~McKinnon Pond uses surface water exclusively (Subsection 3.1, Water Quality). All water diverted from Peat Bog Creek (minus evaporation) is returned after it circulates through the rearing pond (Subsection 3.1, Water Quantity). Under Alternative 2, McKinnon Pond would use approximately 2.0 cfs of surface water from Peat Bog Creek from December through February (Table 14). These are the only months that steelhead are reared at McKinnon Pond and are the months when many streams and rivers experience higher than average flows. Because this water would not be withdrawn under Alternative 1, Alternative 2 would lead to a negligible negative effect on water quantity in Peat Bog Creek between the water intake and discharge structures relative to Alternative 1.~~

~~**Stillaguamish River Basin:** The Whitehorse Ponds Hatchery uses well and surface water (Subsection 3.1, Water Quantity). All water diverted from Whitehorse Springs Creek (minus evaporation) is returned to Whitehorse Springs Creek after it circulates through the hatchery facility (Subsection 3.1, Water Quantity).~~

~~Under Alternative 2, the Whitehorse Ponds Hatchery would use approximately 2.4 cfs of surface water from Whitehorse Ponds Creek to support the early winter steelhead program (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 2 would lead to a negative negligible effect on water quantity in Whitehorse Springs Creek relative to Alternative 1.~~

~~Under Alternative 2, 0.5 cfs of groundwater would be used to support the early winter steelhead hatchery program. Because this water would not be withdrawn under Alternative 1, Alternative 2 may lead to a negative negligible effect on groundwater supply because 0.5 cfs of water would not remain in the aquifer for other water users in contrast to Alternative 1.~~

~~**Skykomish River Basin:** The Wallace River Hatchery uses surface water exclusively (Subsection 3.1, Water Quantity). All water is returned to the Wallace River and May Creek (minus evaporation) after circulating through the facilities (Subsection 3.1, Water Quantity).~~

~~Under Alternative 2, the Wallace River Hatchery would withdraw up to 6.4 cfs from Wallace River and up to 2.2 cfs from May Creek to support the early winter steelhead hatchery program (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 2 would lead to a negligible negative effect on water quantity in the Wallace River and May Creek relative to Alternative 1. Water quantity would only be affected between the water intakes and discharge structures.~~

~~Reiter Ponds withdraws up to 4.9 cfs from Austin Creek and 4.9 cfs from Hogarty Creek (Subsection 3.1, Water Quantity). All water is returned to the river (minus evaporation) after circulating through the facilities. Under Alternative 2, Reiter Ponds would withdraw up to 4.9 cfs from Austin Creek and 4.9 cfs from Hogarty Creek, to support the early winter steelhead hatchery programs (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 2 would lead to a moderate negative effect on water quantity relative to Alternative 1. Water quantity would only be affected between the water intakes and discharge structures.~~

~~**Snoqualmie River Basin:** The Tokul Creek Hatchery uses surface water (Subsection 3.1, Water Quantity). Under Alternative 2, the Tokul Creek Hatchery would temporarily withdraw up to 2.7 cfs from Tokul Creek and up to 5.4 cfs from a spring to support the early winter steelhead hatchery program (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 2 would lead to a negligible negative effect because more of the water would remain in Tokul Creek and in the spring relative to Alternative 1. All water would be returned to the creek after circulating through the hatchery. Water quantity would only be affected between the water intake and discharge structures.~~

4.1.3 Alternative 3 (Reduced Production) – Make a Determination that Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

~~Under Alternative 3, WDFW would reduce proposed production levels by 50 percent, and water use would be reduced by 50 percent relative to Alternative 2. However, relative to Alternative 1, under which the programs would be terminated, both~~

Under Alternative 3, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be reduced by 50 percent, but water would continue to be used to rear other species. Consequently, short- and long-term water use and effects would be the same as under existing conditions and under the other alternatives. ~~short- and long-term water use would be greater under Alternative 3. More water use would negatively affect low flow conditions by increasing the percent of hatchery program water withdrawals (Table 14), and by decreasing ground water supplies where ground water is used, relative to Alternative 1. However, there would be a positive change in effect compared to existing conditions because half of the water withdrawn under existing conditions would be withdrawn under Alternative 3.~~

~~All hatchery facilities would remain in compliance with water permits or water rights under Alternative 3 because less water would be used at the hatchery facilities relative to existing conditions, and all hatchery facilities would comply with required water permits or water rights described under existing conditions (Subsection 3.1, Water Quantity). Analyses of the site-specific effects of Alternative 3 are provided below.~~

~~**Dungeness River Basin:** The Dungeness River Hatchery uses surface water exclusively, withdrawn through three water intakes on the Dungeness River and one on Canyon Creek, an adjacent tributary. All water diverted from Dungeness River and Canyon Creek (minus evaporation) is returned after it circulates through the hatchery facility (Subsection 3.1, Water Quantity). Under Alternative 3, the Dungeness River Hatchery would use approximately 1.0 cfs of surface water from the Dungeness River and 0.2 cfs of water from Canyon Creek to support the early winter steelhead program (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 3 would result in a moderate negative effect on water quantity in the Dungeness River and in Canyon Creek between the water intake and discharge structures relative to Alternative 1.~~

~~Under Alternative 3, the Hurd Creek Hatchery may withdraw up to 0.13 cfs from Hurd Creek to support the early winter steelhead program (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 3 would have a moderate negative effect on water~~

~~quantity in Hurd Creek between the water intake and discharge structures relative to Alternative 1.~~

~~Under Alternative 3, 0.48 cfs more groundwater would be used to support the early winter steelhead hatchery program relative to Alternative 1, which may lead to a low negative effect on groundwater supply relative to Alternative 1.~~

~~**Nooksack River Basin:** Under Alternative 3, the Kendall Creek Hatchery would use approximately 3.4 cfs of surface water from Kendall Creek to support the early winter steelhead program (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 3 may result in a low negative effect on water quantity in Kendall Creek relative to Alternative 1.~~

~~Under Alternative 3, 3.9 cfs of groundwater would be used to support the early winter steelhead hatchery program, and because this water would not be used under Alternative 1, Alternative 3 may lead to a low negative effect on groundwater supply relative to Alternative 1.~~

~~Under Alternative 3, McKinnon Pond would use approximately 1.0 cfs of surface water from Peat Bog Creek from December through February (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 3 would lead to a negligible negative effect on water quantity in Peat Bog Creek between the water intake and discharge structures relative to Alternative 1.~~

~~**Stillaguamish River Basin:** Under Alternative 3, Whitehorse Ponds Hatchery would use approximately 1.2 cfs from Whitehorse Springs Creek. Because this water would not be withdrawn under Alternative 1, Alternative 3 would have a negligible negative effect on water quantity in Whitehorse Springs Creek relative to Alternative 1. Under Alternative 3, 0.3 cfs of groundwater would be used to support the early winter steelhead hatchery program. Because this water would not be withdrawn under Alternative 1, Alternative 3 would lead to a negligible negative effect on groundwater supply relative to Alternative 1.~~

~~**Skykomish River Basin:** Under Alternative 3, the Wallace River Hatchery would withdraw up to 3.2 cfs from Wallace River and up to 1.1 cfs from May Creek to support the early winter steelhead hatchery program (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 3 would lead to a negligible negative effect on water quantity in the Wallace River and May Creek relative to Alternative 1. Water quantity would only be affected between the water intakes and discharge structures.~~

Under Alternative 3, Reiter Ponds would withdraw up to 2.5 cfs from Austin Creek and 2.5 cfs from Hogarty Creek, to support the early winter steelhead hatchery programs (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 3 would lead to a low negative effect on water quantity relative to Alternative 1. Water quantity would only be affected between the water intakes and discharge structures.

Snoqualmie River Basin: The Tokul Creek Hatchery uses surface water (Subsection 3.1, Water Quantity). Under Alternative 3, the Tokul Creek Hatchery would withdraw up to 1.4 cfs from Tokul Creek and up to 2.7 cfs from a spring to support the early winter steelhead hatchery program (Table 14). Because this water would not be withdrawn under Alternative 1, Alternative 3 would lead to a negligible negative effect because more of the water would be left in Tokul Creek and in the spring relative to existing conditions. All water would be returned to the creek after circulating through the hatchery. Water quantity would only be affected between the water intake and discharge structures.

Relative to the Alternative 2 and to existing conditions, Alternative 3 would reduce water use at the eight hatchery facilities that support the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins by the following amounts:

Dungeness River basin: 1.0 cfs from Dungeness River, 0.2 cfs from Canyon Creek, 0.13 cfs from Hurd Creek, and 0.95 cfs from wells (Table 14)

Nooksack River basin: 3.4 cfs from Kendall Creek, 1.0 cfs from Peat Bog Creek, and 3.9 cfs from wells (Table 14)

Stillaguamish River basin: 1.2 cfs from Whitehorse Springs Creek and 0.3 cfs from wells (Table 14)

Skykomish River basin: 3.2 cfs from Wallace River, 1.1 cfs from May Creek, 2.5 cfs from Austin Creek, and 2.5 cfs from Hogarty Creek (Table 14)

Snoqualmie River basin: 1.4 cfs from unnamed spring and 2.7 cfs from Tokul Creek (Table 14).

Because water use would be reduced by 50 percent at the eight hatchery facilities under Alternative 3, effects on surface and groundwater quantity would be low to negligible, localized, and positive, since less water would be used to support the hatchery programs compared to Alternative 2.

4.1.4 Alternative 4 (Native Broodstock) – Make a Determination that Revised HGMPs that Replace Chambers Creek Stock with a Native Broodstock Meet Requirements of the 4(d) Rule

Under Alternative 4, ~~WDFW would produce~~ the same number of hatchery-origin winter steelhead would be produced as under the Alternative 2, but the broodstock source would change from the early winter Chambers Creek stock to native steelhead broodstocks that are local to the river basins. Relative to existing conditions, Alternative 1, and Alternative 2, effects on water quantity would be the same~~ as under Alternative 2~~ because the change in broodstock would not affect water quantity (i.e., the same amount of water would be used in the facilities).

4.1.5 Alternative 5 (Preferred Alternative) – Make a Determination that HGMPs Including a Revised HGMP with Reduced Production Level in Skykomish River Basin Meet Requirements of the 4(d) Rule

Under Alternative 5, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, and Snoqualmie River basins would be the same as under Alternative 2, and the production level for the Skykomish River program would be reduced from 256,000 smolts to 167,600 smolts. Relative to Alternative 1, Alternative 5 would increase the number of early winter steelhead released into the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins by 531,600 smolts, Because water would continue to be used to rear other species, short- and long-term water use and effects would be the same as under existing conditions and Alternative 1 through Alternative 4.

4.2 Salmon and Steelhead

The salmon and steelhead analyses address effects of early winter steelhead hatchery programs proposed under each alternative on existing conditions described in Subsection 3.2, Salmon and Steelhead. ~~when combined with effects anticipated under each alternative.~~ The analysis focuses on natural-origin fish populations that are self-sustaining in the natural environment and are dependent on aquatic habitat for migration, spawning, rearing, and food. This subsection describes effects on salmon and steelhead associated with the alternatives for the effect categories described in Subsection 3.2.2.1, General Effects of Puget Sound Salmon and Steelhead Hatchery Programs as listed below:

- Genetic Risks
- Competition and Predation
- Hatchery Facility Effects
- Masking
- Incidental Fishing Effects
- Disease Transfer
- Mining

- 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 oceanic 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 early winter 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 to salmon and steelhead from other general factors (e.g., habitat, climate change) are described in Chapter 5, Cumulative Effects.

As described in Subsection 1.5.3, NMFS's Determination as to Compliance with the 4(d) Rule, NMFS will require monitoring and evaluation as a condition of its approval under the 4(d) Rule. Further, as described in Subsection 1.6.6, ~~Future~~ Public Review and Comment, additional NEPA and/or ESA review may be needed in the future in response to new information or if different actions are proposed. Monitoring and evaluation under the HGMPs would address performance of the hatchery programs in meeting and adaptively managing their objectives. Subsection 1.2, Description of the Proposed Action, identifies monitoring activities. Monitoring 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 (e.g., Anderson et al. 2014), and juvenile and adult fish health when the fish are in the hatchery. These activities would be the same under the action alternatives, and are not discussed further.

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

Under Alternative 1, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be terminated immediately (Subsection 2.2.1, Alternative 1), and 620,000 fewer early winter steelhead would be produced by hatcheries in the analysis area relative to existing conditions (Subsection 3.2, Salmon and Steelhead). Therefore, all risks to listed ESUs and DPSs, non-listed salmon species, and designated critical habitat associated with these ongoing hatchery programs would be eliminated (Subsection 3.2, Salmon and Steelhead). Relative to existing conditions, Alternative 1 would result in the following effects:

- Gene flow from early winter hatchery-origin steelhead to natural-origin steelhead would be reduced from less than 2 percent or less than 5 percent (depending on the population) under existing conditions to zero (Subsection 3.2.3.1, Genetic Risks), which would result in a low positive effect on natural-origin steelhead populations in the Dungeness, Nooksack, Stillaguamish, and Skykomish River basins, and a low to moderate positive effect in the Snoqualmie River basin, relative to existing conditions. This reduction in gene flow would likely result in a low to moderate (depending on the population) positive effect to the fitness of the populations.

- The risk of predation (direct and indirect) from early winter hatchery-origin steelhead on juvenile fall Chinook salmon, fall chum salmon, pink salmon, and sockeye salmon would be reduced (Subsection 3.2.3.2, Competition and Predation), which would result in a low positive effect on natural-origin populations of these species.

- The risk of competition between hatchery-origin early winter hatchery-origin steelhead and natural-origin steelhead, spring Chinook salmon, and coho salmon would be reduced (Subsection 3.2.3.2, Competition and Predation), which would result in a low positive effect on natural-origin steelhead, spring Chinook salmon, and coho salmon populations.

- Hatchery facility risks would remain the same as under existing conditions (Subsection 3.2.3.3, Hatchery Facility Risks), since all hatchery facilities would continue to operate for other species under Alternative 1. All instream structures (including weirs) would continue to be used and maintained. There would be no change in the hatchery facility compliance~~s~~ with NMFS screening criteria at the Dungeness River Hatchery, Hurd Creek Hatchery, McKinnon Pond, Whitehorse Ponds Hatchery, Wallace River Hatchery, Reiter Ponds, and Tokul Creek Hatchery (Subsection 3.2.3.3, Hatchery Facility Risks). WDFW would be expected to complete its already planned upgrade to the water intake screen at Kendall Creek Hatchery and Wallace River Hatchery, and improve fish passage at the Dungeness River Hatchery and Tokul Creek Hatchery (Subsection 3.2.3.3, Hatchery Facility Risks).

- The risk that the status of natural steelhead would be masked by early winter hatchery-origin steelhead would be reduced from existing conditions to 0 (Subsection 3.2.3.4, Masking), which would result in a negligible positive effect on natural-origin steelhead populations.

- There would be no recreational or tribal steelhead fisheries in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins targeting early winter hatchery-origin steelhead. Therefore, incidental fishing effects (Subsection 3.2.3.5, Incidental Fishing Effects) would be eliminated, which would provide a low positive effect on natural-origin steelhead populations. Early-timed returns of natural-origin winter steelhead would no longer be at risk of interception by fisheries targeting early winter steelhead. The co-managers may consider fisheries for natural-origin steelhead when natural-origin populations are recovered or large enough to support fishing.

- There would be no expected change in the risk of disease transfer since all of the hatchery facilities would continue to propagate other fish species (e.g., salmon or trout), which can harbor many of the same diseases as steelhead (Subsection 3.2.3.6, Risk of Disease Transfer) (Table 10); thus, the risk would be the same as under existing conditions.

- There would be no change in the risk of "mining" natural-origin populations through the collection of broodstock because no natural-origin fish would be incorporated into broodstocks under existing conditions, and there would be no broodstock under Alternative 1 (i.e., the programs would be terminated) (Subsection 3.2.3.7, Risk of "Mining" Natural-origin ~~Salmon and~~ Steelhead) (Table 15). Therefore, there would be no risk to natural-origin steelhead from "mining."

- There would be no change in population viability benefits to natural-origin steelhead populations because early winter hatchery-origin steelhead provide no viability benefits under existing conditions, and there would be no early winter steelhead hatchery programs under Alternative 1 (i.e., the programs would be terminated) (Subsection 3.2.3.8, Population Viability Benefits).

- There would be ~~no change~~a negligible change in the contribution of hatchery-origin steelhead to marine-derived nutrients because hatchery-origin steelhead contributions to nutrients are negligible under existing conditions (Subsection 3.2.3.9, Nutrient Cycling), and would not be impacted under any alternative.

Table 15. Number of natural-origin winter steelhead in the hatchery broodstock by alternative in five early winter steelhead hatchery programs in Puget Sound.

River Basin	Average Natural-origin Winter Run[1]	TRT Interim Viable Abundance Target	Number of Natural-origin Winter Steelhead in Broodstock					
			Existing Conditions	Alt. 1[2]	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Dungeness	530~~487~~	1,232	0	N/A	0	0	Up to 30 with a 1:1 sex ratio	0
Nooksack	1,760	11,023	0	N/A	0	0	Up to 100 with a 1:1 sex ratio	0
Stillaguamish	1,852	9,559	0	N/A	0	0	Up to 120 with a 1:1 sex ratio	0
Snohomish-Skykomish	1,~~,~~683	10,695	0	N/A	0	0	Up to 300 with a 1:1 sex ratio	0
Snohomish-Snoqualmie	955	8,370	0	N/A	0	0	Up to 100 with a 1:1 sex ratio	0

[1] Source: Table 11.
[2] The hatchery programs would be terminated under Alternative 1, so no broodstock would be needed.

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

Under Alternative 2, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would operate as proposed in submitted HGMPs (Subsection 2.2.2, Alternative 2), and release levels (total of 620,000 steelhead) would be the same as under existing conditions (Chapter 3, Affected Environment). Relative to Alternative 1 under which the hatchery programs would be terminated, Alternative 2 would result in the following effects:

- Gene flow from early winter hatchery-origin steelhead would increase from zero under Alternative 1 to less than 2 percent (Subsection 3.2.3.1, Genetic Risks), in the Dungeness, Nooksack, Stillaguamish, ~~and~~ Skykomish, and Snoqualmie River basins, which would result in a low, negative effect on natural-origin steelhead populations.~~, which is the same as under existing conditions. Gene flow would increase from zero to under 5 percent in the Snoqualmie River basins, which would result in a low to moderate negative effect on the natural-origin steelhead population, the same as under existing conditions (Subsection~~

~~3.2.3.1, Genetic Risks).~~ These gene flow levels would likely result in a low negative effect to the fitness of the populations, relative to Alternative 1. Effects of gene flow under Alternative 2 would be less than under existing conditions, because under Alternative 2, gene flow for the Snoqualmie River basin would be reduced from between 2 to 5 percent (low to moderate negative effect) to under 2 percent (low negative effect) (Appendix B, Table B-6). This decrease is primarily related to a reduction in pHOS under Alternative 2, relative to existing conditions (Appendix B, Table B-4).

- The risk of predation (direct and indirect) on juvenile fall Chinook salmon, fall chum salmon, pink salmon, and sockeye salmon would increase relative to Alternative 1 (Subsection 3.2.3.2, Competition and Predation), but hatchery managers would minimize ~~competitive~~ interactions by releasing the early winter hatchery-origin steelhead when they are fully smolted and, thus, actively migrating to marine waters (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e). Therefore, Alternative 2 would result in a low, negative effect on predation of natural-origin fall Chinook salmon, fall chum salmon, pink salmon, and sockeye salmon, which would be the same as under existing conditions (Subsection 3.2.3.2, Competition and Predation).

- The risk of competition between early winter hatchery-origin steelhead and natural-origin steelhead, spring Chinook salmon, and coho salmon would increase relative to Alternative 1 (Subsection 3.2.3.2, Competition and Predation), but hatchery managers would minimize competitive interactions by releasing the hatchery-origin steelhead when they are fully smolted and thus, actively migrating to marine waters (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e). Therefore, Alternative 2 would result in a low, negative effect on competition with natural-origin steelhead, spring Chinook salmon, and coho salmon populations, which would be the same as under existing conditions (Subsection 3.2.3.2, Competition and Predation).

- Hatchery facility risks would remain the same as under existing conditions (Subsection 3.2.3.3, Hatchery Facility Risks), since all hatchery facilities would continue to operate under both Alternative 1 and Alternative 2, and all instream structures (including weirs) would continue to be used and maintained. There would be no change in the hatchery facilities' compliance with NMFS screening criteria at Dungeness River Hatchery, Hurd Creek Hatchery, McKinnon Pond, Whitehorse Ponds Hatchery, Wallace River Hatchery, Reiter Ponds, and Tokul Creek hatchery (Subsection 3.2.3.3, Hatchery Facility Risks). As under Alternative 1, WDFW would be expected to complete its already planned upgrade to the water intake screen at Kendall Creek Hatchery and Wallace River Hatchery, and improve fish passage at the Dungeness River Hatchery and Tokul Creek Hatchery (Subsection 3.2.3.3, Hatchery Facility Risks).

- The risk that the status of natural-origin steelhead would be masked by early winter hatchery-origin steelhead would increase as compared to Alternative 1, but would still result in a negligible negative effect because of differences in return timing, which would be the same as under existing conditions (Subsection 3.2.3.4, Masking).

- Unlike under Alternative 1, there would be harvest-oriented recreational steelhead fisheries in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, and tribal fisheries for early winter hatchery-origin steelhead in terminal areas. Therefore, negative incidental fishing effects from recreational and tribal fisheries would be greater than under Alternative 1. However, similar to existing conditions (Subsection 3.2.3.5, Incidental Fishing Effects), the negative incidental fishing impacts on the natural-origin populations (including potential re-expression of early-timed returns of natural-origin winter steelhead) would be low, because (1) 100 percent of the hatchery-origin fish would be marked and recreational fisheries would be mark-selective, so impacts to unmarked natural-origin fish would be limited to hook-and-release mortalities associated with fish that are legally caught and then released back into the water, (2) the run timing of the early winter hatchery-origin and natural-origin steelhead populations is sufficiently separate, allowing harvest managers to continue to design and implement fisheries to avoid most effects on natural-origin fish (although there would be an increase in the vulnerability to harvest of early-timed returns of natural-origin winter steelhead relative to Alternative 1) , and (3) cool water temperatures during the months when the recreational steelhead fishery is open would minimize incidental hook-and-release mortality of natural-origin steelhead (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e).

- There would be no expected change in the risk of disease transfer since all of the hatchery facilities would continue to propagate other fish species (e.g., salmon or trout), as under Alternative 1, which harbor many of the same diseases as steelhead (Subsection 3.2.3.6, Risk of Disease Transfer) (Table 10); therefore, the risk would be the same as under existing conditions.

- There would be no change in the risk of "mining" natural-origin populations through the collection of broodstock because no natural-origin fish would be incorporated into the broodstock under Alternative 1 or Alternative 2, or under existing conditions

(Subsection 3.2.3.7, Risk of "Mining" Natural-origin ~~Salmon and~~ Steelhead) (Table 15). Therefore, there would be no risk to natural-origin steelhead from "mining."

- There would be no change in population viability benefits to natural-origin steelhead populations because early winter hatchery-origin steelhead provide no viability benefits under Alternative 1 or under existing conditions (Subsection 3.2.3.8, Population Viability Benefits), and releases of early winter hatchery-origin steelhead under Alternative 2 would provide no population viability benefits to natural origin-steelhead.

4.2.3 Alternative 3 (Reduced Production) – Make a Determination that Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

Under Alternative 3, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be reduced by 50 percent (to a total of 315,000 steelhead) relative to the proposed hatchery programs (Subsection 2.2.3, Alternative 3), which would be 50 percent less than under existing conditions (Subsection 3.2, Salmon and Steelhead). Relative to Alternative 1 under which the hatchery programs would be terminated, Alternative 3 would result in the following effects:

- Gene flow from early winter hatchery-origin steelhead (Subsection 3.2.3.1, Genetic Risks), would increase from zero under Alternative 1 to less than 2 percent which would result in a low negative effect on natural-origin steelhead populations in the Dungeness, Nooksack, Stillaguamish, ~~and~~ Skykomish, and Snoqualmie River Basins. Gene flow would increase from zero to ~~under 5 percent in the Snoqualmie River basins, which would result in a low to moderate~~ a low negative effect on the natural-origin steelhead population. This gene flow would likely result in a low negative effect to the fitness of the populations, relative to Alternative 1.

- The risk of predation (direct and indirect) on juvenile fall Chinook salmon, fall chum salmon, pink salmon, and sockeye salmon would increase relative to Alternative 1 (Subsection 3.2.3.2, Competition and Predation), but hatchery managers would minimize ~~competitive~~ interactions by releasing the early winter hatchery-origin steelhead when they are fully smolted, and, thus, actively migrating to marine waters (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e). Therefore, Alternative 3 would result in a low, negative effect on predation of natural-origin fall Chinook salmon, fall chum salmon, pink salmon, and sockeye salmon.

- The risk of competition between hatchery-origin steelhead and natural-origin steelhead, spring Chinook salmon, and coho salmon would increase relative to Alternative 1 (Subsection 3.2.3.2, Competition and Predation), but hatchery managers would minimize competitive interactions by releasing the early winter hatchery-origin steelhead when they are fully smolted, and, thus, actively migrating to marine waters (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e). Therefore, Alternative 3 would result in a low, negative effect on competition with natural-origin steelhead, spring Chinook salmon, and coho salmon populations.

- Hatchery facility risks would be the same as under existing conditions (Subsection 3.2.3.3, Hatchery Facility Risks) and Alternative 1, since all hatchery facilities would continue to operate under both Alternative 1 and Alternative 3, and all instream structures (including weirs) would continue to be used and maintained. There would be no change in the hatchery facilities' compliance with NMFS screening criteria at Dungeness River Hatchery, Hurd Creek Hatchery, McKinnon Pond, Whitehorse Ponds Hatchery, Wallace River Hatchery, Reiter Ponds, and Tokul Creek Hatchery (Subsection 3.2.3.3, Hatchery Facility Risks). As under Alternative 1, WDFW would be expected to complete its already planned upgrade to the water intake screen at Kendall Creek Hatchery and Wallace River Hatchery, and improve fish passage at the Dungeness River Hatchery and Tokul Creek Hatchery (Subsection 3.2.3.3, Hatchery Facility Risks).

- The risk that the status of natural-origin steelhead would be masked by early winter hatchery-origin steelhead would increase relative to Alternative 1, but would still result in a negligible negative effect because of differences in run timing between the hatchery and natural-origin populations, which would be the same as under existing conditions (Subsection 3.2.3.4, Masking).

- Unlike under Alternative 1, there would be harvest-oriented recreational steelhead fisheries in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, and tribal fisheries for early winter hatchery-origin steelhead in terminal areas. Therefore, negative incidental fishing effects from recreational and tribal fisheries would be greater than under Alternative 1. However, similar to existing conditions (Subsection 3.2.3.5, Incidental Fishing Effects), the negative incidental fishing impacts on the natural-origin population (including potential re-expression of early-timed returns of natural-origin winter steelhead) would be low, because (1) 100 percent of the hatchery-origin fish would be marked and recreational fisheries would be mark-selective, so impacts to unmarked natural-origin fish would be limited to hook-and-release mortalities associated with fish that are legally caught and then released back into the water, (2) the adult return timing for the early winter hatchery-origin and natural-origin steelhead populations is sufficiently separate, allowing harvest managers to design and implement fisheries to avoid most effects on natural-origin fish (although there would be an increase in the vulnerability to harvest of early-timed returns natural-origin winter steelhead relative to Alternative 1), and (3) cool water temperatures during the months when the recreational steelhead fishery is open would minimize incidental hook-and-release mortality of natural-origin steelhead (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e).

- There would be no expected change in the risk of disease transfer since all of the hatchery facilities would continue to propagate other fish species (e.g., salmon or trout) as under Alternative 1, which harbor many of the same diseases as steelhead (Subsection 3.2.3.6, Risk of Disease Transfer) (Table 10); therefore the risk would be the same as under existing conditions.

- There would be no change in the risk of "mining" the natural-origin population through the collection of broodstock because no natural-origin fish would be incorporated into the broodstock under Alternative 1 or Alternative 3, or under existing conditions (Subsection 3.2.3.7, Risk of "Mining" Natural-origin Steelhead) (Table 15). Therefore, there would be no risk to natural-origin steelhead from "mining."

- There would be no change in population viability benefits to natural-origin steelhead populations because early winter hatchery-origin steelhead provide no viability benefits under Alternative 1 or under existing conditions (Subsection 3.2.3.8, Population Viability Benefits), and releases of early winter hatchery-origin steelhead under Alternative 3 would provide no population viability benefits to natural origin-steelhead.

Relative to Alternative 2 and existing conditions, Alternative 3 would result the following effects:

- Less gene flow, competition and predation risks, and incidental fishing effects because fewer hatchery-origin fish would be released under Alternative 3 relative to Alternative 2 and existing conditions. However, these risks would be low under both alternatives for reasons discussed above.

- The same hatchery facility risks as under Alternative 2 and existing conditions, because the hatchery facilities would continue to operate under both alternatives.

- The same risk of masking as under Alternative 2 and existing conditions, although fewer hatchery-origin fish would be released under Alternative 3 relative to Alternative 2. However, these negative risks would be negligible under both alternatives because of differences in return timing between hatchery-origin and natural-origin steelhead.
- The same risk of disease transfer as under Alternative 2 and existing conditions, since all of the hatchery facilities would continue to propagate other fish species (e.g., salmon or trout), which harbor many of the same diseases as steelhead.
- The same lack of risk of "mining" the natural-origin population through the collection of broodstock as under Alternative 2 and existing conditions, because no natural-origin fish would be incorporated into the broodstock under either alternative.
- The same lack of population viability benefits to natural-origin steelhead populations as under Alternative 2 and existing conditions, because early winter hatchery-origin steelhead provide no viability benefits, and early winter hatchery-origin steelhead would be released under Alternative 2 and Alternative 3.

4.2.4 Alternative 4 (Native Broodstock) – Make a Determination that Revised HGMPs that Replace Chambers Creek Stock with a Native Broodstock Meet Requirements of the 4(d) Rule

Under Alternative 4, ~~WDFW would produce~~ over time, the same number of hatchery-origin winter steelhead would be produced as under Alternative 2 (total of 620,000 steelhead) and under existing conditions, but the broodstock source would change from the early winter Chambers Creek stock to native steelhead broodstocks that are local to the respective river basins (Subsection 2.2.4, Alternative 4). The programs would be intended to provide conservation benefits, as well as potential harvest benefits once the depressed natural-origin steelhead populations become large enough. A considerable transition period may be necessary to achieve harvest objectives. Relative to Alternative 1 under which the hatchery programs would be terminated, Alternative 4 would result in the following effects:

- Gene flow from hatchery-origin steelhead to natural-origin steelhead would increase from zero under Alternative 1 to up to 10 percent under Alternative 4 (Subsection 2.4.4, Alternative 4). Higher gene flow is intended in hatchery programs using native broodstock (integrated hatchery programs) so that the genetic characteristics of the hatchery-origin fish are similar to those of the natural-origin fish. Even though the gene flow between natural-origin steelhead populations and hatchery-origin steelhead would be higher than under Alternative 2, Alternative 3, and existing conditions, the higher gene flow levels would have a low risk of harmful genetic effects on natural-origin steelhead populations in the

Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins because the broodstock would be derived from the local native populations (Subsection 3.2.3.1, Genetic Risks) (HSRG 2009).

- Predation (direct and indirect) on juvenile fall Chinook salmon, fall chum salmon, pink salmon, and sockeye salmon would increase relative to Alternative 1 (Subsection 3.2.3.2, Competition and Predation), but hatchery managers would minimize ~~competitive~~ interactions by releasing the hatchery-origin steelhead when they are fully smolted, and, thus, actively migrating to marine waters (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e). Therefore, Alternative 4 would result in a low, negative effect on predation of natural-origin fall Chinook salmon, fall chum salmon, pink salmon, and sockeye salmon, which would be the same as under existing conditions (Subsection 3.2.3.2, Competition and Predation).

- Competition between hatchery-origin steelhead and natural-origin steelhead, spring Chinook salmon, and coho salmon would increase relative to Alternative 1 (Subsection 3.2.3.2, Competition and Predation), but hatchery managers would minimize competitive interactions by releasing the hatchery-origin steelhead when they are fully smolted, and, thus, actively migrating to marine waters (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFWe). Therefore, Alternative 4 would result in a low, negative effect on competition with natural-origin steelhead, spring Chinook salmon, and coho salmon populations, which would be the same as under existing conditions (Subsection 3.2.3.2, Competition and Predation).

- Hatchery facility risks would remain the same as under existing conditions (Subsection 3.2.3.3, Hatchery Facility Risks) and Alternative 1 since all hatchery facilities would continue to operate under both Alternative 1 and Alternative 4, and all instream structures (including weirs) would continue to be used and maintained. There would be no change in the hatchery facilities' compliance with NMFS screening criteria at Dungeness River Hatchery, Hurd Creek Hatchery, McKinnon Pond, Whitehorse Ponds Hatchery, Wallace River Hatchery, Reiter Ponds, and Tokul Creek Hatchery (Subsection 3.2.3.3, Hatchery Facility Risks). As under Alternative 1, WDFW would be expected to complete its already planned upgrade to the water intake screen at Kendall Creek Hatchery and Wallace River Hatchery, and improve fish passage at the Dungeness River Hatchery and Tokul Creek Hatchery (Subsection 3.2.3.3, Hatchery Facility Risks).

- The risk that the status of natural-origin steelhead would be masked by hatchery-origin steelhead would increase as compared to Alternative 1 and existing conditions, because the adult return and spawn timing of the hatchery-origin fish would be similar to natural-origin steelhead. However, masking would have a low negative effect because all hatchery-origin fish would be marked as under existing conditions (Subsection 3.2.3.4, Masking).

- Unlike under Alternative 1, under Alternative 4, when returns of natural-origin winter steelhead are large enough, there would be recreational steelhead fisheries in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, and tribal fisheries targeting hatchery-origin fish. In addition, compared to Alternative 1, due to the similarity in adult return timing of hatchery-origin and natural-origin steelhead under Alternative 4, and greater encounter rates with natural-origin steelhead, negative incidental fishing effects would be greater ~~than under Alternative 1~~, especially for tribal fisheries that typically use non-selective fishing gear (e.g., nets). However, similar to existing conditions (Subsection 3.2.3.5, Incidental Fishing Effects), the overall negative incidental fishing impacts on the natural-origin population would be low because (1) 100 percent of the hatchery-origin fish would be marked and recreational fisheries would be mark-selective, so impacts to unmarked natural-origin fish would be limited to hook-and-release mortalities associated with fish that are legally caught and then released back into the water, (2) recreational and tribal harvest managers would design fisheries to focus effort on hatchery-origin fish, and (3) cool water temperatures during the months when the recreational steelhead fishery is open would minimize incidental hook-and-release mortality of natural-origin steelhead (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014d; WDFW 2014e).

- There would be no expected change in the risk of disease transfer since all of the hatchery facilities would continue to propagate other fish species (e.g., salmon or trout), as under Alternative 1, which harbor many of the same diseases as steelhead (Subsection 3.2.3.6, Risk of Disease Transfer) (Table 10), which would be the same as under existing conditions.

- While there is generally a risk of “mining” the natural-origin population through the collection of broodstock when a hatchery program incorporates natural-origin fish into the broodstock (Subsection 3.2.3.7, Risk of “Mining” Natural-origin ~~Salmon and~~ Steelhead), and natural-origin steelhead populations are depressed in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins (Table 15), in this case, the risk would be low under Alternative 4, because broodstock collection would be contingent upon availability of natural-origin fish, ensuring that an appropriate minimum number of fish would be able to spawn naturally; and only after that threshold is ensured would a proportion of additional returns be taken into the hatchery facilities.

- In contrast to Alternative 1, Alternative 2, Alternative 3, and under existing conditions, where no viability benefits to natural-origin steelhead would occur, it is possible that the viability of natural-origin steelhead would benefit under Alternative 4 (Subsection 3.2.3.8, Population Viability Benefits), primarily through use of local, native broodstocks whose returns would increase population abundance (including potential early-timed returns of natural-origin winter steelhead), and could help to conserve genetic diversity and productivity of the depressed natural-origin populations.

Relative to Alternative 2 and existing conditions, Alternative 4 would result in the following effects:

- Alternative 4 would result in higher levels of gene flow because hatchery-origin steelhead derived from local, native steelhead populations would have a more similar return and spawn timing, compared to the hatchery-origin steelhead derived from Chambers Creek early winter steelhead lineage (Figure 1). However, because the hatchery-origin fish would be derived from the local, native steelhead populations, these higher levels of gene flow would provide a similar genetic effect from gene flow on fitness (low negative) as the less than 2 percent gene flow under Alternative 2 and under existing conditions.

- Alternative 4 would result in the same levels of competition and predation risks (low, negative) as under Alternative 2 and existing conditions, because the same number of hatchery-origin fish would be released under both alternatives.

- Hatchery facility risks would remain the same as under Alternative 2 and existing conditions because all hatchery facilities would continue to operate under both Alternative 2 and Alternative 4, and all instream structures (including weirs) would continue to be used and maintained.

- The risk that the status of natural-origin steelhead would be masked by hatchery-origin steelhead would increase under Alternative 4 relative to Alternative 2 and existing conditions, because the adult return and spawn timing of the hatchery-origin fish would be more similar to natural-origin steelhead. However, Alternative 4 would still result in a low negative effect because all hatchery-origin steelhead would be marked, similar to Alternative 2 and under existing conditions.

- Incidental fishing effects may be greater under Alternative 4 relative to Alternative 2 and existing conditions, because the hatchery-origin fish derived from local, native broodstocks would have the same run timing as natural-origin steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, the ability to design fisheries to avoid natural-origin fish may be reduced, and so more natural-origin steelhead would be subjected to incidental capture and release.

- There would be no expected change in the risk of disease transfer under Alternative 4, Alternative 2, and existing conditions since all of the hatchery facilities would continue to propagate other fish species (e.g., salmon or trout), which harbor many of the same diseases as steelhead.

- While there is generally a risk of "mining" the natural-origin population through the collection of broodstock when a hatchery program incorporates natural-origin fish into the broodstock, and natural-origin steelhead populations are depressed in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins (Table 15). In this case, the risk would be negligible under Alternative 4, because broodstock collection would be contingent upon availability of natural-origin fish, ensuring that an appropriate minimum number of fish would be able to spawn naturally; and only after that threshold is ensured would a proportion of additional returns be taken into the hatchery facilities.

- In contrast to Alternative 1, Alternative 2, and under existing conditions, where no viability benefits to natural-origin steelhead would occur from releases of early winter hatchery-origin steelhead, it is possible that the viability of natural-origin steelhead would benefit under Alternative 4, primarily through use of local, native broodstocks whose returns would increase population abundance, and could help to conserve genetic diversity and productivity of the depressed natural-origin populations.

4.2.5 Alternative 5 (Preferred Alternative) – Make a Determination that HGMPs Including a Revised HGMP with Reduced Production Levels in Skykomish River Basin Meet Requirements of the 4(d) Rule

Under Alternative 5, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, and Snoqualmie River basins would be the same as under Alternative 2, and the production level for the Skykomish River program would be reduced from 256,000 smolts to 167,600 smolts (Subsection 2.2.5, Alternative 5), relative to existing conditions (Subsection 3.2, Salmon and Steelhead). This would lead to relatively small and localized short- and long-term changes in effects relative to existing conditions and the other alternatives. Relative to Alternative 1, under which the hatchery programs would be terminated, Alternative 5 would increase the number of early winter steelhead released into the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins by 531,600 smolts. Alternative 5 would result in the following effects:

- Gene flow from early winter hatchery-origin steelhead (Subsection 3.2.3.1, Genetic Risks), would increase from zero under Alternative 1 to less than 2 percent, which would result in a low negative effect on natural-origin steelhead populations in all basins. This gene flow would likely result in a low negative effect to the fitness of all populations.

- The risk of predation (direct and indirect) on juvenile fall Chinook salmon, fall chum salmon, pink salmon, and sockeye salmon would increase relative to Alternative 1 (Subsection 3.2.3.2, Competition and Predation), but hatchery managers would minimize interactions by releasing the early winter hatchery-origin steelhead when they are fully smolted, and, thus, actively migrating to marine waters (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014e; WDFW 2016). Therefore, Alternative 5 would result in a low negative effect on predation of natural-origin fall Chinook salmon, fall chum salmon, pink salmon, and sockeye salmon.

- The risk of competition between hatchery-origin steelhead and natural-origin steelhead, spring Chinook salmon, and coho salmon would increase relative to Alternative 1 (Subsection 3.2.3.2, Competition and Predation), but hatchery managers would minimize competitive interactions by releasing the early winter hatchery-origin steelhead when they are fully smolted, and, thus, actively migrating to marine waters (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014e; WDFW 2016). Therefore, Alternative 5 would result in a low negative effect on competition with natural-origin steelhead, spring Chinook salmon, and coho salmon populations.

- Hatchery facility risks would be the same as under existing conditions (Subsection 3.2.3.3, Hatchery Facility Risks) and Alternative 1, since all hatchery facilities would continue to operate under both Alternative 1 and Alternative 5, and all instream structures (including weirs) would continue to be used and maintained. There would be no change in the hatchery facilities' compliance with NMFS screening criteria at Dungeness River Hatchery, Hurd Creek Hatchery, McKinnon Pond, Whitehorse Ponds Hatchery, Wallace River Hatchery, Reiter Ponds, and Tokul Creek Hatchery (Subsection 3.2.3.3, Hatchery Facility Risks). As under Alternative 1, WDFW would be expected to complete its already planned upgrade to the water intake screens at Kendall Creek Hatchery and Wallace River Hatchery, and improve fish passage at the Dungeness River Hatchery and Tokul Creek Hatchery (Subsection 3.2.3.3, Hatchery Facility Risks).

- The risk that the status of natural-origin steelhead would be masked by early winter hatchery-origin steelhead would increase relative to Alternative 1, but would still result in a negligible negative effect because of differences in run timing between the hatchery-origin and natural-origin populations, which would be the same as under existing conditions (Subsection 3.2.3.4, Masking).

- Unlike under Alternative 1, there would be harvest-oriented recreational steelhead fisheries in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, and tribal fisheries for early winter hatchery-origin steelhead in terminal areas. Therefore, negative incidental fishing effects from recreational and tribal fisheries would be greater than under Alternative 1. However, similar to existing conditions (Subsection 3.2.3.5, Incidental Fishing Effects), the negative incidental fishing impacts on the natural-origin population (including potential re-expression of early-timed returns of natural-origin winter steelhead) would be low, because (1) 100 percent of the hatchery-origin fish would be marked and recreational fisheries would be mark-selective, so impacts to unmarked natural-origin fish would be limited to hook-and-release mortalities associated with fish that are legally caught and then released back into the water, (2) the adult return timing for the early winter hatchery-origin and natural-origin steelhead populations is sufficiently separate, allowing harvest managers to design and implement fisheries to avoid most effects on natural-origin fish (although there would be an increase in the vulnerability to harvest of early-returning natural-origin winter steelhead relative to Alternative 1), and (3) cool water temperatures during the months when the recreational steelhead fishery is open would minimize incidental hook-and-release mortality of natural-origin steelhead (WDFW 2014a; WDFW 2014b; WDFW 2014c; WDFW 2014e: WDFW 2016).

- There would be no expected change in the risk of disease transfer since all of the hatchery facilities would continue to propagate other fish species (e.g., salmon or trout) as under Alternative 1, which harbor many of the same diseases as steelhead (Subsection 3.2.3.6, Risk of Disease Transfer) (Table 10). Therefore the risk would be the same as under existing conditions.

- There would be no change in the risk of "mining" the natural-origin population through the collection of broodstock because no natural-origin fish would be incorporated into the broodstock under Alternative 1 or Alternative 5, or under existing conditions (Subsection 3.2.3.7, Risk of "Mining" Natural-origin Steelhead) (Table 15). Therefore, there would be no risk to natural-origin steelhead from "mining."

- There would be no change in population viability benefits to natural-origin steelhead populations because early winter hatchery-origin steelhead provide no viability benefits under

Alternative 1 or under existing conditions (Subsection 3.2.3.8, Population Viability Benefits), and releases of early winter hatchery-origin steelhead under Alternative 5 would provide no population viability benefits to natural origin-steelhead.

Relative to Alternative 2 and existing conditions, Alternative 5 would result the following effects:

- Under Alternative 5, 88,400 fewer steelhead would be released into the Skykomish River basin. This would result in corresponding decreases in low gene flow, competition and predation risk, and incidental fishing effects under Alternative 5 relative to Alternative 2 and existing conditions. Decreases in effects would be relatively small and localized compared to Alternative 2. The decrease in numbers of steelhead released under Alternative 5 would result in improved confidence in evaluations of gene flow effects relative to Alternative 2.

- Hatchery facility risks would be the same as under Alternative 2 and existing conditions, because the hatchery facilities would continue to operate under both alternatives.

- The risk of masking would be the same as under Alternative 2 and existing conditions, although fewer hatchery-origin fish would be released under Alternative 5 relative to Alternative 2. However, these negative risks would be negligible under both alternatives because of differences in return timing between hatchery-origin and natural-origin steelhead.

- The risk of disease transfer would be the same as under Alternative 2 and existing conditions, since all of the hatchery facilities would continue to propagate other fish species (e.g., salmon or trout), which harbor many of the same diseases as steelhead.

- The lack of risk of "mining" the natural-origin population through the collection of broodstock would be the same as under Alternative 2 and existing conditions, because no natural-origin fish would be incorporated into the broodstock under either alternative.

- The lack of population viability benefits to natural-origin steelhead populations would be the same as under Alternative 2 and existing conditions, because early winter hatchery-origin steelhead provide no viability benefits, and early winter hatchery-origin steelhead would be released under Alternative 2 and Alternative 5.

4.3 Other Fish Species

The analyses of other fish species address effects of early winter steelhead hatchery programs proposed under each alternative on existing conditions for other fish species described in Subsection 3.3, Other Fish Species~~, when combined with effects anticipated under each alternative~~. The analysis focuses on natural-origin fish populations that are self-sustaining in the natural environment and are dependent on aquatic habitat for migration, spawning, rearing, and food.

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

Under Alternative 1, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be terminated immediately (Subsection 2.2.1, Alternative 1), and 620,000 fewer steelhead would be produced by hatcheries in the analysis area relative to existing conditions (Subsection 3.2, Salmon and Steelhead). The reduction in early winter hatchery-origin steelhead in the river basins would result in a short- and long-term reduction in competition for space and food among freshwater species relative to existing conditions (Subsection 3.3, Other Fish Species). There would also be a reduction in predation risk by hatchery-origin steelhead on other fish species, and a potentially measurable reduction in the number of prey eaten by hatchery-origin steelhead in the analysis area, relative to existing conditions.

However, because (1) the analysis area is only a small portion of each species' range and (2) hatchery-origin steelhead are not exclusive predators or prey for any of the fish species, including bull trout, Alternative 1 would be expected to have a negligible effect on other fish species (positive for some species and negative for others) relative to existing conditions. Consequently, Alternative 1 would not be expected to change any short- or long-term 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 Requirements of the 4(d) Rule

Under Alternative 2, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would operate as proposed in submitted HGMPs (Subsection 2.2.2, Alternative 2). Relative to Alternative 1, Alternative 2 would increase the number of hatchery-origin steelhead produced in the analysis area by 620,000 smolts, which would be the same as under existing conditions (Subsection 3.3, Other Fish Species). Therefore, there would be a short- and long-term increase in risk of competition for space and food among freshwater species relative to Alternative 1. There would also be an increase in the risk of predation by hatchery-origin steelhead on other fish species, and a potentially measurable increase in the number of prey eaten by steelhead in the analysis area relative to Alternative 1, which would be similar to existing conditions.

However, because (1) the analysis area is only a small portion of each species' range, and (2) steelhead are not exclusive predators or prey for any of the fish species, including bull trout, Alternative 2 would be expected to have negligible effects (positive for fish that eat steelhead and negative for other fish that are eaten by steelhead) relative to Alternative 1. Consequently, Alternative 2 would not be expected to change any short- or long-term risks to other fish species or State or Federal species designations relative to Alternative 1 or to existing conditions (Subsection 3.3, Other Fish Species).

4.3.3 Alternative 3 (Reduced Production) – Make a Determination that Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

Under Alternative 3, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be reduced by 50 percent relative to Alternative 2 (Subsection 2.2.3, Alternative 3). Relative to Alternative 1 under which the hatchery programs would be terminated, Alternative 3 would increase the number of juvenile steelhead released into the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins by 310,000 smolts, which would lead to a short- and long-term increase in the risk of competition for space and food among freshwater species relative to Alternative 1. There would also be an increase in the risk of predation by steelhead on other fish species, and a potentially measurable increase in the number of prey eaten by steelhead in the analysis area relative to Alternative 1.

However, because (1) the analysis area is only a small portion of each species' range, and (2) steelhead are not exclusive predators or prey for any of the fish species, Alternative 3 would also be expected to have negligible effects (positive for fish that eat steelhead and negative for fish that are eaten by steelhead), including bull trout, relative to Alternative 1. Consequently, Alternative 3 would not be expected to change any short- or long-term risks to other fish species or State or Federal species designations relative to Alternative 1 (Subsection 3.3, Other Fish Species).

Relative to existing conditions and to Alternative 2, Alternative 3 would release 310,000 fewer steelhead into the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, which would lead to a short- and long-term reduction in the risk of competition for space and food among freshwater species relative to Alternative 2 and existing conditions. There would also be a reduction in the risk of predation by steelhead on other fish species, and a potentially measurable reduction in the number of prey eaten by steelhead in the analysis area relative to Alternative 2 and existing conditions.

However, because (1) the analysis area is only a small portion of each species' range, and (2) steelhead are not exclusive predators or prey for any of the fish species, Alternative 3 would also be expected to have a negligible effect on other fish species (positive for fish that are eaten by steelhead and negative for fish that eat steelhead), including bull trout, relative to Alternative 2. Consequently, Alternative 3 would not be expected to change any State or Federal species designations relative to Alternative 2 and existing conditions (Subsection 3.3, Other Fish Species).

4.3.4 Alternative 4 (Native Broodstock) – Make a Determination that Revised HGMPs that Replace Chambers Creek Stock with a Native Broodstock Meet Requirements of the 4(d) Rule

Under Alternative 4, relative to Alternative 1, the same number of hatchery-origin winter steelhead would be produced as under Alternative 2 and under existing conditions, but the broodstock source would change from the early winter Chambers Creek stock to native steelhead broodstocks that are local to the respective river basins (Subsection 2.2.4, Alternative 4). Effects on other fish species, including bull trout, would be identical to those under Alternative 2 (negligible) and existing conditions (Subsection 3.3, Other Fish Species), because a change in broodstock would not affect ecological interactions between hatchery-origin steelhead and other fish species.

4.3.5 Alternative 5 (Preferred Alternative) – Make a Determination that HGMPs Including Revised HGMP with Reduced Production Levels in Skykomish River Basin Meet Requirements of the 4(d) Rule

Under Alternative 5, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, and Snoqualmie River basins would be the same as under Alternative 2, and the production level for the Skykomish River program would be reduced from 256,000 smolts to 167,600 smolts (Subsection 2.2.5, Alternative 5), relative to existing conditions (Subsection 3.2, Salmon and Steelhead). Relative to Alternative 1, Alternative 5 would increase the number of early winter steelhead released into the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins by 531,600 smolts, which would lead to a short- and long-term increase in the risk of competition for space and food among freshwater species relative to Alternative 1. There would also be an increase in the risk of predation by steelhead on other fish species, and a potentially measurable increase in the number of prey eaten by steelhead in the analysis area relative to Alternative 1.

However, because (1) the analysis area is only a small portion of each species' range, and (2) steelhead are not exclusive predators or prey for any of the fish species, Alternative 5 would also be expected to have negligible effects (positive for fish that eat steelhead and negative for fish that are eaten by steelhead), including bull trout, relative to Alternative 1. Consequently, Alternative 5 would not be expected to change any short- or long-term risks to other fish species or State or Federal species designations relative to Alternative 1 (Subsection 3.3, Other Fish Species).

Relative to existing conditions and to Alternative 2, under Alternative 5, 88,400 fewer steelhead would be released into the Skykomish River basin, which would lead to a relatively small and localized short- and long-term reduction in the risk of competition for space and food among freshwater species. There would also be a small and localized reduction in the risk of predation by steelhead on other fish species, and a potentially measurable reduction in the number of prey eaten by steelhead in the analysis area relative to Alternative 2 and existing conditions.

However, because (1) the analysis area is only a small portion of each species' range, and (2) steelhead are not exclusive predators or prey for any of the fish species, Alternative 5 would be expected to have a negligible effect on other fish species (positive for fish that are eaten by steelhead and negative for fish that eat steelhead), including bull trout, relative to Alternative 2. Consequently, Alternative 5 would not be expected to change any State or Federal species designations relative to Alternative 2 and existing conditions (Subsection 3.3, Other Fish Species).

4.4 Wildlife – Southern Resident Killer Whale

The analysis of wildlife resources addresses effects of early winter steelhead hatchery programs on Southern Resident killer whales. As described in Subsection 3.4, Wildlife – Southern Resident Killer Whale, effects of salmon and steelhead hatchery programs on wildlife species would be expected to be 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, as under existing conditions. Therefore, wildlife species in the analysis area are not analyzed in this EIS, with the exception of Southern Resident killer whales (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

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

Under Alternative 1, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be terminated immediately (Subsection 2.2.1, Alternative 1), and fewer steelhead (juvenile and adult) would be available as a food source for Southern Resident killer whales (Subsection 3.4, Wildlife – Southern Resident Killer Whale). Because (1) Alternative 1 would only lead to a small reduction in the total number of steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins or in the analysis area, and (2) Southern Resident killer whales do not feed exclusively on steelhead, Alternative 1 would be expected to have a negligible negative effect on the diet, survival, distribution and listing status of the species relative to the negligible positive effect under existing conditions (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

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

Under Alternative 2, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would operate as proposed in the submitted HGMPs (Subsection 2.2.2, Alternative 2). Consequently, relative to Alternative 1, more steelhead (juveniles and adults) would be available as a food source for Southern Resident killer whales (Subsection 3.4, Wildlife – Southern Resident Killer Whale). Because (1) Alternative 2 would only lead to a small increase in the total number of steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins or in the analysis area relative to Alternative 1, and (2) Southern Resident killer whales do not feed exclusively on steelhead, Alternative 2 would be expected to have a negligible positive effect on the diet, survival, distribution and listing status of the species relative to Alternative 1, similar to effects under existing conditions (Subsection 3.4, Wildlife-Southern Resident Killer Whale).

4.4.3 Alternative 3 (Reduced Production) – Make a Determination that Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

Under Alternative 3, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be reduced by 50 percent relative to the proposed hatchery programs (Subsection 2.2.3, Alternative 3). Relative to Alternative 1 under which the hatchery programs would be terminated, Alternative 3 would increase the number of juvenile steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins, and more steelhead (juveniles and adults) would be available as a food source for Southern Resident killer whales (Subsection 3.4, Wildlife – Southern Resident Killer Whale). Because (1) Alternative 3 would only lead to a small increase in the total number of salmon and steelhead in the Dungeness, Nooksack, Stillaguamish River, Skykomish, and Snoqualmie basins or in the analysis area relative to Alternative 1, and (2) Southern Resident killer whales do not feed exclusively on steelhead, Alternative 3 would be expected to have negligible positive effects on the diet, survival, distribution, and listing status of the species relative to Alternative 1, and effects would be similar to the negligible positive effects under existing conditions (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

Relative to existing conditions and Alternative 2, Alternative 3 would reduce the number of hatchery-origin steelhead released in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins by 50 percent and, therefore, reduce the total number of steelhead available as food to Southern Resident killer whales. Because (1) Alternative 3 would reduce the total number of juvenile hatchery-origin steelhead in the analysis area by a very small percentage relative to the total number of salmon and steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie basin or in the analysis area relative to existing conditions and Alternative 2, and (2) Southern Resident killer whales do not feed exclusively on steelhead, Alternative 3 would be expected to have a similar, but less ~~pronounced~~ negligible positive effect on the diet, survival, distribution, and listing status of the species relative to existing conditions or Alternative 2.

4.4.4 Alternative 4 (Native Broodstock) – Make a Determination that Revised HGMPs that Replace Chambers Creek Stock with a Native Broodstock Meet Requirements of the 4(d) Rule

Under Alternative 4, ~~WDFW~~ the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would produce the same number of winter

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hatchery-origin steelhead (620,000) as under Alternative 2, but would replace the early winter Chambers Creek steelhead broodstock with native steelhead broodstocks that are local to the respective river basins (Subsection 2.2.4, Alternative 4). Effects on Southern Resident killer whales would be identical to those under Alternative 2 (negligible positive) and existing conditions, because a change in broodstock would not affect the number or availability of hatchery-origin steelhead available to Southern Resident killer whales as prey.

4.4.5 Alternative 5 (Preferred Alternative) – Make a Determination that HGMPs Including a Revised HGMP with Reduced Production Levels in Skykomish River Basin Meet Requirements of the 4(d) Rule

Under Alternative 5, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, and Snoqualmie River basins would be the same as under Alternative 2, and the production level for the Skykomish River program would be reduced from 256,000 yearlings to 167,600 yearlings (Subsection 2.2.5, Alternative 5), relative to existing conditions (Subsection 3.2, Salmon and Steelhead). Relative to Alternative 1, under which the hatchery programs would be terminated, Alternative 5 would increase the number of juvenile steelhead in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins by 531,600 smolts, and more returning steelhead (adults) would be available as a food source for Southern Resident killer whales (Subsection 3.4, Wildlife – Southern Resident Killer Whale). Because (1) Alternative 5 would represent 3 percent of the total number of salmon and steelhead released into the analysis area relative to Alternative 1 (531,600 smolts out of the 160 million salmon and steelhead released into Puget Sound, see Table Y in Chapter 3), and (2) Southern Resident killer whales do not feed exclusively on adult steelhead (preferring Chinook salmon), Alternative 5 would be expected to have negligible positive effects on the diet, survival, distribution, and listing status of the species relative to Alternative 1, and effects would be similar to the negligible positive effects under existing conditions (Subsection 3.4, Wildlife – Southern Resident Killer Whale).

Relative to existing conditions and Alternative 2, under Alternative 5, 88,400 fewer hatchery-origin steelhead smolts would be released in the Skykomish River basin, which would lead to a reduction in the total number of steelhead (adults) available as food to Southern Resident killer whales. Because (1) Alternative 5 would reduce the total number of hatchery-origin steelhead in the analysis area by an unsubstantial amount relative to the total number of salmon and steelhead released in the analysis area (160 million) relative to existing conditions and Alternative 2, and (2) Southern Resident killer whales do not feed exclusively on adult steelhead (preferring Chinook salmon), Alternative 5 would be expected to have a similar, but less negligible positive effect on the diet, survival, distribution, and listing status of the species relative to existing conditions or Alternative 2.

4.5 Socioeconomics

The socioeconomic analysis addresses effects of early winter steelhead hatchery programs on existing socioeconomic conditions of regional and local economies described in Subsection 3.5, Socioeconomics, when combined with effects anticipated under each alternative. This assessment of the socioeconomic effects of the alternatives evaluates predicted changes in recreational trips, hatchery operational cost values (e.g., procurement of goods and services needed to operate hatcheries), and personal income and jobs associated with fisheries on early winter hatchery-origin steelhead that would contribute to economic conditions in the analysis area.

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

Under Alternative 1, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be terminated immediately (Subsection 2.2.1, Alternative 1), and 620,000 fewer steelhead would be produced by hatcheries in the analysis area relative to existing conditions (Subsection 3.2, Salmon and Steelhead). However, all of the hatchery facilities that support these hatchery programs would continue to operate because they support hatchery programs (e.g., for salmon) that are not part of the Proposed Action or its alternatives (Subsection 3.5, Socioeconomics).

None of the 19.3 FTE jobs supporting the five early winter steelhead hatchery programs would be affected under Alternative 1, compared to existing conditions, because the hatchery facilities would be used for production of other species (e.g., salmon) (Subsection 3.5.1, Hatchery Operations; Appendix C, Socioeconomics Methods). However, the hatchery programs would no longer need to procure local goods and services, which would lead to a loss of $496,000 that would have low negative impact to personal income and jobs in the regional economy, relative to existing conditions (Subsection 3.5.1, Hatchery Operations).

NMFS estimates that early winter steelhead from the hatchery programs produce 4,412 adults that contribute $5.3 million from annual angler expenditures associated with 78,400 fishing trips in the analysis area under existing conditions (Subsection 3.5.2, Fisheries), which would not occur under Alternative 1. The overall economic loss of $5.8 million under Alternative 1 ($496,000 plus $5.3 million) would have a moderate negative effect on socioeconomic resources in the analysis area, relative to existing conditions.

Under Alternative 1, the number of steelhead available to tribal members as a food source would be reduced, which may increase tribal reliance on other fish species or consumer goods~~, or increase travel costs to participate in other steelhead fisheries~~, relative to existing conditions. Further, Alternative 1 would reduce the amount of revenue that could be generated by tribes through the harvest and sale of steelhead. Therefore, Alternative 1 would be expected to have a moderate negative effect on affected tribes, relative to existing conditions.

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

Under Alternative 2, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would operate as proposed in the submitted HGMPs (Subsection 2.2.2, Alternative 2). Relative to Alternative 1, Alternative 2 would increase the number of hatchery-origin steelhead produced in the analysis area by 620,000 smolts, which would be the same as under existing conditions (Subsection 3.2, Salmon and Steelhead).

None of the 19.3 FTE jobs supporting the five early winter steelhead hatchery programs would be affected under Alternative 2~~Relative to Alternative 1, Alternative 2 would increase jobs by 19.3 FTE to support the five early winter steelhead hatchery programs~~, which is the same as under existing conditions (Subsection 3.5.1, Hatchery Operations; Appendix C, Socioeconomics Methods). The hatchery programs would procure local goods and services, which would contribute $496,000 and have a low positive impact on personal income and jobs in the regional economy (Subsection 3.5.1, Hatchery Operations).

Relative to Alternative 1, hatchery production under Alternative 2 would produce 4,412 adults (Appendix C, Socioeconomics Methods) which would contribute $5.3 million from annual angler expenditures associated with 78,400 fishing trips in the analysis area. The overall economic contribution of $5.8 million under Alternative 2 ($496,000 plus $5.3 million) would be the same as under existing conditions, and would have a moderate positive effect on the socioeconomic resources in the analysis areas, relative to Alternative 1.

Relative to Alternative 1, Alternative 2 would increase the number of steelhead available to tribal members as a food source and may reduce tribal reliance on other species or consumer goods, or reduce travel costs to participate in other fisheries (Subsection 3.5, Socioeconomics). Further, relative to Alternative 1, Alternative 2 would increase the amount of revenue that could be generated by tribes through the sale of fish. These effects would, however, continue to represent existing conditions. Therefore, Alternative 2 would be expected to have a moderate positive effect on affected tribes, relative to Alternative 1, but no change in effect relative to existing conditions.

4.5.3 Alternative 3 (Reduced Production) – Make a Determination that Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

Under Alternative 3, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be reduced by 50 percent relative to the submitted HGMPs (Subsection 2.2.3, Alternative 3), and relative to existing conditions. Relative to

Alternative 1, Alternative 3 would increase the number of hatchery-origin steelhead produced in the analysis area by 310,000 smolts.

None of the 19.3 FTE jobs supporting the five early winter steelhead hatchery programs would be affected under Alternative 3, because the hatchery facilities would be used for production of other species (e.g., salmon) (Subsection 3.5.1, Hatchery Operations; Appendix C, Socioeconomics Methods). However, under Alternative 3, expenditures on goods and services needed to operate the hatchery programs would be reduced (estimated at about $65,000), relative to Alternative 2 and existing conditions (Appendix C, Socioeconomics Methods), which would have a negligible negative~~positive~~ impact on personal income and jobs in the regional economy (Subsection 3.5.1, Hatchery Operations)

Relative to Alternative 1, hatchery production under Alternative 3 would produce 2,206 adults (Appendix C, Socioeconomics Methods) which would contribute $4.4 million from annual angler expenditures associated with 59,800 fishing trips in the analysis area. The overall economic contribution of $4.8 million under Alternative 3 ($431,000 plus $4.4 million) would have a moderate positive effect on the socioeconomic resources in the analysis areas, relative to Alternative 1. This effect would be the same as under existing conditions.

Relative to Alternative 1, Alternative 3 would increase the number of steelhead available to tribal members as a food source and may reduce tribal reliance on other consumer goods or reduce travel costs to participate in other fisheries (Subsection 3.5, Socioeconomics). Further, relative to Alternative 1, Alternative 3 would increase the amount of revenue that could be generated through the sale of fish. Such increases would not likely match existing food source availability and revenues, however, because hatchery production would decrease 50 percent compared to existing conditions. Therefore, Alternative 3 would be expected to have a low positive effect on affected tribes, relative to Alternative 1.

Relative to existing conditions and Alternative 2, Alternative 3 would reduce the number of hatchery-origin steelhead released in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins[2]. This would reduce the total number of steelhead harvested annually in recreational fisheries in

[2] As explained in Appendix C, Socioeconomics Methods, it is assumed that changes in operation and maintenance costs would be proportional to differences between production levels under the alternatives. In contrast, labor income from the five hatchery programs under the Alternative 1 (No Action), ~~and~~ Alternative 3 (Reduced Production), and Alternative 5 (Preferred Alternative), is assumed to remain the same as estimated for the Proposed Action (Alternative 2), because no jobs are assumed to be lost under any alternative due to operations for programs (e.g., salmon) not included in the Proposed Action. However, under Alternative 1, ~~and~~ Alternative 3, and Alternative 5, regional income generated by expected changes in hatchery-related expenditures associated with procurement of goods and services and from angler expenditures, would change, because procurement spending to achieve the production levels, and associated recreational angler effort, would change under the alternatives.

the river basins from about 4,412 to 2,206 adults, associated angler effort would decline by an estimated 19,600 trips (25 percent) to 59,800 trips, and overall regional economic income would be reduced $1.0 million to $4.8 million, relative to Alternative 2 and existing conditions.

Relative to existing conditions and Alternative 2, Alternative 3 also would reduce the number of 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 (Subsection 3.5, Socioeconomics). Further, relative to existing conditions and Alternative 2, Alternative 3 would reduce the amount of revenue that could be generated by tribes through the sale of fish.

4.5.4 Alternative 4 (Native Broodstock) – Make a Determination that Revised HGMPs that Replace Chambers Creek Stock with a Native Broodstock Meet Requirements of the 4(d) Rule

Under Alternative 4, relative to Alternative 1, the same number of hatchery-origin winter steelhead would be produced as under existing conditions and Alternative 2, but the broodstock source would change from the early winter Chambers Creek stock to native steelhead broodstocks that are local to the respective river basins (Subsection 2.2.4, Alternative 4). As described in Appendix C, Socioeconomic Methods, under Alternative 4, it is assumed that the smolt-to-adult survival rates of fish from early winter hatchery programs would be similar to smolt-to-adult survival rates of fish from native broodstocks, and therefore over time, the harvest-related socioeconomic effects of Alternative 4 would not differ from existing conditions or Alternative 2. Impacts would be expected during the transition period from early winter steelhead broodstock to native broodstock. Therefore, socioeconomic effects would be less in the short term, but identical to those under existing conditions and Alternative 2 (moderate positive effect) because over time, the same number of fish would be produced and harvested.

4.5.5 Alternative 5 (Preferred Alternative) – Make a Determination that HGMPs Including a Revised HGMP with Reduced Production Levels in Skykomish River Basin Meet Requirements of the 4(d) Rule

Under Alternative 5, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, and Snoqualmie River basins would be the same as under Alternative 2, and the production level for the Skykomish River program would be reduced from 256,000 smolts to 167,600 smolts (Subsection 2.2.5, Alternative 5), relative to existing conditions (Subsection 3.2, Salmon and Steelhead). Under Alternative 5, the total number of steelhead smolts released would decrease by 88,400 smolts, relative to Alternative 2 and existing conditions. Relative to Alternative 1, Alternative 5 would increase the total number of early winter steelhead released into the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins by 531,600 smolts, None of the 19.3 FTE jobs supporting the five early winter steelhead hatchery programs would be affected under Alternative 5 because the hatchery facilities would be used for production of other species (e.g., salmon) (Subsection 3.5.1, Hatchery Operations; Appendix C, Socioeconomics Methods). However, under Alternative 5, expenditures on goods and services needed to operate the hatchery programs would be reduced (estimated at about $19,000), relative to Alternative 2 and existing conditions (Appendix C, Socioeconomics Methods), which would have a negligible negative impact on personal income and jobs in the regional economy (Subsection 3.5.1, Hatchery Operations).

Relative to Alternative 1, hatchery production under Alternative 5 would produce 3,633 adult steelhead (Appendix C, Socioeconomics Methods), which would support $4.9 million from annual angler expenditures associated with 72,912 fishing trips in the analysis area. The overall economic contribution of $5.4 million under Alternative 5 ($477,000 plus $4.9 million) would have a moderate positive effect on the socioeconomic resources in the analysis areas, relative to Alternative 1. This effect would be the same as under existing conditions.

Relative to Alternative 1, Alternative 5 would increase the number of steelhead available to tribal members as a food source and may reduce tribal reliance on other consumer goods (Subsection 3.5, Socioeconomics). Further, relative to Alternative 1, Alternative 5 would increase the amount of revenue that could be generated through the sale of fish. Total hatchery production would decrease by 88,400 smolts compared to existing conditions; however, Alternative 5 would be expected to have an overall moderate positive effect on affected tribes relative to Alternative 1. This effect would be the same as under existing conditions.

Relative to existing conditions and Alternative 2, Alternative 5 would reduce the number of hatchery-origin steelhead released in Skykomish River basin. In addition, under Alternative 5 the total number of steelhead harvested annually in recreational fisheries in the river basins would decrease from about 4,412 to 3,633 adults, associated angler effort would decline by an estimated 5,488 trips (7 percent) to 72,912 trips, and overall regional economic income would be reduced $369,000 to $5.4 million, relative to Alternative 2 and existing conditions.

Relative to existing conditions and Alternative 2, Alternative 5 also would reduce the number of steelhead available to tribal members as a food source and may increase tribal reliance on other consumer goods (Subsection 3.5, Socioeconomics). Furthermore, relative to existing conditions and Alternative 2, Alternative 5 would reduce the amount of revenue that could be generated by tribes through the sale of fish.

4.6 Environmental Justice

The environmental justice analysis addresses effects of early winter steelhead hatchery programs on existing environmental justice conditions in the analysis area described in Subsection 3.6, Environmental Justice, when combined with effects anticipated under each alternative.

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

Under Alternative 1, the early winter steelhead hatchery programs would be terminated immediately (Subsection 2.2.1, Alternative 1), and 620,000 fewer steelhead would be produced by hatcheries in the analysis area relative to existing conditions (Subsection 3.2, Salmon and Steelhead).As a result, there would be a loss of fishing opportunities in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins relative to existing conditions. All four of the counties in the analysis area are environmental justice communities of concern because they meaningfully deviate from thresholds for low income or minority populations (Subsection 3.6, Environmental Justice) (Table 13). Therefore, overall, all counties in the analysis area would be similarly affected by the termination of the early winter steelhead hatchery programs and loss of fishing opportunities under Alternative 1 would result in low and negative environmental justice impacts, relative to existing conditions (Subsection 3.6, Environmental Justice). The most substantial impacts would be expected on the 13 communities of concern that are associated with steelhead fishing. Clallam County and Whatcom County may be affected to a greater extent than Snohomish and King Counties because per capita income and the percentage of persons below the poverty level are the highest.

Because of the unique connection of Native American tribes to salmon and steelhead, any reduction in steelhead harvest opportunities pose a disproportionate effect on Native American tribes. Therefore, Alternative 1 would have a moderate negative impact on the following tribes: Lummi Nation, Nooksack Tribe, Stillaguamish Tribe of Indians~~ Tribe~~, Tulalip Tribes, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Lower Elwha Klallam Tribe, relative to existing conditions (Subsection 3.6, Environmental Justice).

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

Under Alternative 2, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would operate as proposed in the submitted HGMPs (Subsection 2.2.2, Alternative 2). Relative to Alternative 1, Alternative 2 would increase the number of hatchery-origin steelhead produced in the analysis area by 620,000 smolts, which would be the same as under existing conditions (Subsection 3.2, Salmon and Steelhead). Relative to Alternative 1, Alternative 2 would increase fishing opportunities in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. However, such increases in fishing opportunities would be at the same level as under current, existing conditions (Subsection 3.6, Environmental Justice).

Overall, all counties in the environmental justice analysis area would be similarly affected by implementation of the proposed HGMPs and fishing opportunities under Alternative 2, which would result in low positive effects, relative to Alternative 1. However, the low positive effects would continue to represent existing conditions. The most substantial impacts would be expected on the 13 communities of concern that are associated with steelhead fishing. Clallam County and Whatcom County may be affected to a greater extent than Snohomish and King Counties because per capita income and the percentage of persons below the poverty level are the highest.

Because of the unique connection of Native American tribes to salmon and steelhead, any changes in harvest opportunity would pose a disproportionate effect on Native American tribes if the change reduces harvest in their "usual and accustomed" fishing areas. Because Alternative 2 would increase harvest opportunities for tribes in the analysis area relative to Alternative 1, there would be a moderate positive impact on the following tribes: Lummi Nation, Nooksack Tribe, Stillaguamish Tribe of Indians~~ Tribe~~, Tulalip Tribes, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Lower Elwha Klallam Tribe. However, such increases in harvest opportunities would be at the same levels as under current, existing conditions (Subsection 3.6, Environmental Justice).

4.6.3 Alternative 3 (Reduced Production) – Make a Determination that Revised HGMPs with Reduced Production Levels Meet Requirements of the 4(d) Rule

Under Alternative 3, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins would be reduced by 50 percent relative to the proposed hatchery programs (Subsection 2.2.3, Alternative 3), and 310,000 fewer steelhead would be produced in the analysis area relative to existing conditions (Subsection 3.2, Salmon and Steelhead). Relative to Alternative 1 under which the hatchery programs would be terminated, Alternative 3 would increase fishing opportunities in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. Such increases would not be at the same levels as under current, existing conditions (Subsection 3.6, Environmental Justice).

Overall, all counties in the environmental justice analysis area would be similarly affected by implementation of the proposed HGMPs and fishing opportunities under Alternative 3~~2~~, which would result in low positive effects relative to Alternative 1, which would be similar to existing conditions. The most substantial impacts would be expected on the 13 communities of concern that are associated with steelhead fishing. Clallam County and Whatcom County may be affected to a greater extent than

Snohomish and King Counties because per capita income and the percentage of persons below the poverty level are the highest.

Because of the unique connection of Native American tribes to salmon and steelhead, any changes in harvest opportunity would pose a disproportionate effect on Native American tribes if the change reduces harvest in their "usual and accustomed" fishing areas. Because Alternative 3 would increase harvest opportunities for tribes in the analysis area relative to Alternative 1, there would be a moderate, positive impact on the following tribes: Lummi Nation, Nooksack Tribe, Stillaguamish Tribe of Indians~~ Tribe~~, Tulalip Tribes, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Lower Elwha Klallam Tribe. This benefit would, however, be lower than under existing conditions (Subsection 3.6, Environmental Justice).

Relative to existing conditions and Alternative 2, Alternative 3 would reduce harvest opportunities for tribes in the analysis area. Consequently, there would be a moderate negative impact on the following tribes: Lummi Nation, Nooksack Tribe, Stillaguamish Tribe of Indians~~ Tribe~~, Tulalip Tribes, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Lower Elwha Klallam Tribe.

4.6.4 Alternative 4 (Native Broodstock) – Make a Determination that Revised HGMPs that Replace Chambers Creek Stock with a Native Broodstock Meet Requirements of the 4(d) Rule

Under Alternative 4, ~~WDFW would produce~~ the same number of hatchery-origin winter steelhead would be produced as under Alternative 2, but the broodstock source would change from the early winter Chambers Creek steelhead stock to native broodstocks that are local to the river basins (Subsection 2.2.4, Alternative 4). Impacts would be expected during the transition period from early winter steelhead broodstock to native broodstock. However, e~~E~~nvironmental justice effects would be identical to those under Alternative 2 (low positive to environmental justice counties of concern, and moderate positive for affected tribes) because the change in broodstock would over time lead to the same number of hatchery-origin steelhead available for harvest.

4.6.5 Alternative 5 (Preferred Alternative) – Make a Determination that HGMPs including a Revised HGMP with Reduced Production Levels in Skykomish River Basin Meet Requirements of the 4(d) Rule

Under Alternative 5, the early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, and Snoqualmie River basins would be the same as under Alternative 2, except that the production level for the Skykomish River program would be reduced from 256,000 smolts to 167,600 smolts (Subsection 2.2.5, Alternative 5), relative to existing conditions (Subsection 3.2, Salmon and Steelhead). Relative to Alternative 1 under which the hatchery programs would be terminated, Alternative 5 would increase the total number of early winter steelhead released into the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins by 531,600 smolts, and would increase fishing opportunities in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. Such increases would not be at the same levels as under current, existing conditions (Subsection 3.6, Environmental Justice).

Overall, all counties in the environmental justice analysis area would be similarly affected by implementation of the proposed HGMPs and fishing opportunities under Alternative 5, which would result in low positive effects relative to Alternative 1, which would be similar to existing conditions. The most substantial impacts would be expected on the 13 communities of concern that are associated with steelhead fishing. Clallam County and Whatcom County may be affected to a greater extent than Snohomish and King Counties because per capita income and the percentage of persons below the poverty level are the highest.

Because of the unique connection of Native American tribes to salmon and steelhead, any changes in harvest opportunity would pose a disproportionate effect on Native American tribes if the change reduces harvest in their "usual and accustomed" fishing areas. Because Alternative 5 would increase harvest opportunities for tribes in the analysis area relative to Alternative 1, there would be a moderate, positive impact on the following tribes: Lummi Nation, Nooksack Tribe, Stillaguamish Tribe of Indians, Tulalip Tribes, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Lower Elwha Klallam Tribe. This benefit would, however, be lower than under existing conditions (Subsection 3.6, Environmental Justice). Relative to existing conditions and to Alternative 2, under Alternative 5 fewer steelhead would be released into the Skykomish River basin, which would lead to a localized negative impact on tribal harvest opportunity in that basin.

4.7 Summary of Resource Effects

This subsection provides a summary of potential direct and indirect environmental effects on the physical, biological, and social environments 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 (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)

Table 16 summarizes predicted effects from implementation of the No-action Alternative (Alternative 1) and the action alternatives (Alternative 2 through Alternative 5 ~~Alternative 4~~). This table summarizes the detailed resource discussions in Subsection 4.1, Water Quantity, through Subsection 4.6, Environmental Justice. Refer to those subsections for context and background to support conclusions stated in Table 16. ~~No preferred alternative has been identified in this draft EIS (Subsection 2.4, Selection of a Preferred Alternative and an Environmentally Preferred Alternative).~~

1 Table 16. Summary of environmental consequences by resource and alternative.

Resource	Alternative 1 (No Action – termination)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Reduced Production)	Alternative 4[1] (Native Broodstock)	Alternative 5[1] (Preferred Alternative)
Water Quantity	Compared to existing conditions, the early winter steelhead hatchery programs would be terminated, but all of the hatchery facilities that support the programs would continue to operate to produce fish for programs that are not part of the Proposed Action. Short- and long-term water use may be less than under existing conditions because no early winter steelhead would be produced.	The hatchery programs would continue to operate at existing levels, and would have negligible to moderate negative effects on water quantity, depending on the hatchery program, compared to Alternative 1.	Effects on water quantity would be the same as Alternative 2, because all of the hatchery facilities that support the programs would continue to operate to produce fish for programs that are not part of the Proposed Action.. Same as Alternative 2, although water use would be reduced to support lower production levels of early winter steelhead.	Same as Alternative 32.	Same as Alternative 3.
Salmon and Steelhead	Because early winter steelhead hatchery production would be terminated, negative and positive effects to salmon or steelhead from the programs would be eliminated, compared to existing conditions.	The hatchery programs would continue to operate at existing levels, and would generally have negligible to low moderate negative effects on gene flow, competition and predation, hatchery facilities, masking, incidental fishing, and disease transfer effects; and negligible positive effects from nutrient cycling, depending on the hatchery program and affected species. As under existing conditions, there would be no benefit to the population viability of the listed steelhead DPS.	Same as Alternative 2, except that negative effects from gene flow, competition and predation, hatchery facilities, masking, incidental fishing, and disease transfer from early winter steelhead would be reduced. There would be no change to the population viability benefit of the listed steelhead DPS, compared to Alternative 2.	Same as Alternative 2 except that collection of local native broodstock could have a low negative effect on the abundance and spatial structure of the natural-origin populations (i.e., mining), and a potential positive benefit to viability of the listed steelhead DPS.	Similar to Alternative 2, except that negative and positive effects would be less than Alternative 2, but greater than Alternative 3.

Table 16. Summary of environmental consequences by resource and alternative. (continued)

Resource	Alternative 1 (No Action – termination)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Reduced Production)	Alternative 4[1] (Native Broodstock)	Alternative 5[1] (Preferred Alternative)
Other Fish Species	Because early winter steelhead hatchery production would be terminated, other fish species would be affected if they compete with, are prey of (positive effect), or prey on (negative effect) early winter steelhead, compared to existing conditions.	The hatchery programs would continue to operate at existing levels, and would have low negative to negligible positive effects on other fish species if they compete with or are prey of (negative effect), or prey on fish from early winter steelhead hatchery programs (positive effect), compared to Alternative 1.	Same as Alternative 2, except that the food supply for fish species that benefit from steelhead as prey would be reduced, and risk to other fish species that compete with, are prey of, or prey on steelhead would be reduced, compared to Alternative 2.	Same as Alternative 2.	Similar to Alternative 2, except that negative and positive effects and would be less than Alternative 2, but greater than Alternative 3.
Wildlife – Southern Resident killer whale	Because early winter steelhead hatchery production would be terminated, early winter steelhead prey that would have been available to Southern Resident killer whales under existing conditions would be eliminated. This reduction from existing conditions would likely result in a negligible negative effect.	The hatchery programs would continue to operate at existing levels, and would have a negligible positive effect on Southern Resident killer whales, which would continue to occupy their existing habitats with a similar abundance, and would continue to prey on salmon and steelhead, especially Chinook salmon, compared to Alternative 1.	Similar to Alternative 2, except that early winter steelhead hatchery production and adult returns would decrease, reducing the supply of early winter steelhead available to Southern Resident killer whales as prey. Alternative 3 would have a less negligible positive effect than, ~~similar to~~ Alternative 2~~, but less pronounced~~.	Same as Alternative 2.	Similar to Alternative 2, except that positive effects and would be less than Alternative 2, but greater than Alternative 3.

Table 16. Summary of environmental consequences by resource and alternative. (continued)

Resource	Alternative 1 (No Action – termination)	Alternative 2[1] (Proposed Action)	Alternative 3[1] (Reduced Production)	Alternative 4[1] (Native Broodstock)	Alternative 5[1] (Preferred Alternative)
	Southern Resident killer whales would continue to occupy their existing habitats with a similar abundance, and would continue to prey on available salmon and other steelhead, especially Chinook salmon, as under existing conditions.				
Socioeconomics	Because early winter steelhead hatchery production would be terminated, non-tribal and tribal fishing opportunities would be reduced and there would be a loss of personal income and jobs compared to existing conditions.	The hatchery programs would continue to operate at existing levels, and would have low to moderate positive socioeconomic effects from hatchery operations and fishing activities (non-tribal and tribal), compared to Alternative 1.	Same as Alternative 2, except that the socioeconomic effects from hatchery operations and fishing (non-tribal and tribal) would decrease.	Same as Alternative 2.	Similar to Alternative 2, except that positive effects and would be less than Alternative 2, but greater than Alternative 3.
Environmental Justice	Because early winter steelhead hatchery production would be terminated, reduced fishing opportunities would negatively impact all communities of concern, and affected Native American tribes, compared to existing conditions.	The hatchery programs would continue to operate at existing levels, and would provide low positive effects from fishing opportunities for all communities of concern, and moderate positive effects for Native American tribes, compared to Alternative 1.	Same as Alternative 2, except that fishing opportunities for all communities of concern, and for Native American tribes, would decrease.	Same as Alternative 2.	Similar to Alternative 2, except that positive effects and would be less than Alternative 2, but greater than Alternative 3.

[1] Potential differences between the no action and the action alternatives would be due to differences in hatchery production levels and program type under the action alternatives.

Chapter 5

5 CUMULATIVE EFFECTS

5.1 Introduction

The National Environmental Policy Act 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). Council on Environmental Quality (CEQ) guidelines recognize that it is not practical to analyze the cumulative effects of an action from every conceivable perspective, but rather, the intent is to focus on those effects that are truly meaningful. In other words, if several separate actions have been taken or are intended to be taken within the same geographic area, all of the relevant actions together (cumulatively) need to be reviewed, to determine whether the actions *together* could have a significant impact on the human environment. Past, present, and reasonably foreseeable future actions include those that are Federal and non-Federal. For this EIS analysis, they also include those that are hatchery-related (e.g., hatchery production levels) and non-hatchery related (e.g., human development).

The cumulative effects of a Proposed Action can be represented as an equation:

Proposed Action + Past Actions + Present Actions + Reasonably Foreseeable Future Actions = Cumulative Effects

The CEQ provides an 11-step process for cumulative effects analyses that is woven into the larger NEPA process and into documents supporting a Federal action (CEQ 1997) (Table 17). Other subsections of this EIS are relevant as support for this cumulative effects analysis.

Chapter 3, Affected Environment, describes the existing conditions (or baseline, for the purposes of this chapter) for each resource and reflects the effects of past actions and present condition. Chapter 4, Environmental Consequences, evaluates the direct and indirect effects of the alternatives on each resource’s baseline 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.

Table 17. CEQ cumulative effects analysis process and documentation within this EIS.

		Steps in the Process	Location within this EIS
Scoping	1	Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals	Subsections 1.2, 1.3, 1.6, and 5.5
	2	Establish the geographic scope for the analysis	Subsections 1.4 and 5.1.1
	3	Establish the time frame for the analysis	Subsection 5.1.1
	4	Identify other actions affecting the resources, ecosystems, and human communities of concern	Subsection 5.4
Describing the Affected Environment	5	Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses	Chapter 3
	6	Characterize the stresses affecting these resources, ecosystems, and human communities and relations to regulatory thresholds	
	7	Define a baseline condition for the resources, ecosystems and human communities	
Determining the Environmental Consequences	8	Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities	Chapter 3 and Subsections 5.2 to 5.5
	9	Determine the magnitude and significance of cumulative effects	Subsection 5.6
	10	Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects	Chapter 2
	11	Monitor the cumulative impacts of the selected alternatives and apply adaptive management	Alternative 5 (Preferred Alternative) including monitoring and adaptive management as described in HGMPs

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 additionally includes the entire United States and Canadian portions of the Strait of Juan de Fuca, Strait of Georgia, and all connecting channels and adjoining waters, all of which encompasses an area collectively known as the Salish Sea. The area is also commonly referred to as the Georgia Basin, Strait of Juan de Fuca, and Puget Sound ecosystem. This cumulative effects area was determined based on the geography, topography, waterways, and natural interactions that occur among the ecosystems present in Puget Sound. Biological resources and human populations within the Salish Sea cumulative effects area share a common airshed, common watershed, and common flyway. The developed area has a population of approximately 7 million people with some population projections to 9.4 million by 2025 (Environment Canada-EPA 2008).

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 EIS project area.

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 the cumulative effects analysis area; Subsection 5.3, Present Conditions, describes current overall trends for the area; and Subsection 5.4, Future Actions and Conditions, describes climate change effects, 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 alternatives, when possible.

5.2 Past Actions

Humans have occupied the shores and islands of the Salish Sea for many millennia (Gunther 1950) ~~at least the past 8,000 years (Stein 2000)~~. Before Europeans arrived in the Salish Sea 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 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, substantial 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 (British Columbia Ministry of Water, Land, and Air Protection [BCMWLAP] 2002; 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. As a result, the number of marine-related species at risk in the Salish Sea ecosystem increased, as did the presence of non-native invasive species (Quinn 2010).

Salmon and steelhead have been propagated in hatcheries in Puget Sound since the late 1800s (PSTT and WDFW 2004). The purpose of early hatchery programs was to support recreational and commercial fisheries as compensation for declining natural-origin fish populations due to overexploitation. 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 on natural-origin salmon and steelhead survival and productivity.

In the 1970s, the legal framework of *United States* v. *Washington* (1974) was established that became the primary driver for defining fish production and harvest objectives in Puget Sound (PSTT and WDFW 2004). In general, risks to natural-origin salmon and steelhead (e.g., competition and predation in freshwater 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, of Appendix B, Hatchery Effects and Evaluation Methods for Fish, in the PS Hatcheries DEIS [NMFS 2014a]).

The Pacific Salmon Treaty between Canada and the United States was finalized March 17, 1985 (Pacific Salmon Commission 1985), and has provided 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 role of the Pacific Salmon Commission is 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 is salmon, it is charged with taking into account the conservation of steelhead trout while fulfilling its other functions.

5.3 Present Conditions

As described in Subsection 5.2, Past Actions, substantial changes have occurred to land uses and the marine environment in the Salish Sea cumulative effects analysis area, but the area remains one of the most ecologically diverse in North America, containing a wide range of species and habitats that span international boundaries (EPA 2011). The topography of the area 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 it supports 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 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 Puget Sound, and the area 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 Salish Sea 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 in Puget Sound. Habitat degradation due to human-dominated uses continues to occur to the 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 and British Columbia, has grown over time and has the potential to affect other aquatic organisms.~~

The legal framework of *United States* v. *Washington* (1974) continues to be the primary driver for defining fish production and harvest objectives in Puget Sound. The current Pacific Salmon Treaty agreement (or annex) governs Chinook salmon and several other species from 2009 through 2018.

As described in Subsection 3.2.2.1, General Effects of Puget Sound Salmon and Steelhead Hatchery Programs, the co-managers release a total of about 160 million juvenile hatchery-origin salmon and steelhead into Puget Sound freshwater and marine areas each year, including 47.4 million Chinook salmon, 14.9 million coho salmon, 50 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). In addition, aquaculture (farming of fish, shellfish, and aquatic plants in fresh and marine water for direct harvest), which is practiced in Washington and British Columbia, has grown over time and has the potential to affect other aquatic organisms.

Salmon and steelhead hatchery facilities and practices have become more sophisticated and efficient over time as new technologies have been applied. For example, although the general risks to natural-origin salmon and steelhead (e.g., competition and predation in freshwater and marine water, genetics) from hatchery programs and associated benefits for fisheries as described Subsection 5.2, Past Actions, are ongoing, risks are being reduced from development of contemporary policies 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, 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 actively managing unintended natural spawning and straying by hatchery-origin fish. 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, while simultaneously 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 in the Salish Sea through genetic introgression, competition, predation and disease.

Altogether, the stressors described above under present conditions (e.g., human 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, human development, planned restoration activities, hatchery production, and fisheries. Many plans, regulations, and laws are in place, as well as agreements between the United States and Canada, to ~~minimize~~ reduce effects of development and to restore habitat function. However, 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 for several reasons: (1) the activities may not have yet been formally proposed, (2) mitigation measures specific to future actions may not have been identified for many proposed projects, and (3) there is uncertainty whether mitigation measures for these actions will be fully implemented. However, when combined with climate change, a general trend in expected cumulative effects can be estimated for each resource as described in Subsection 5.5, Cumulative Effects by Resource.

Because of the large geographic scope of this analysis, it is not feasible to conduct a detailed assessment of all project-level activities that have occurred, are occurring, or are planned in the future for the cumulative effects analysis area. Rather, 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 contribute to those trends.

5.4.1 Climate Change

The changing climate is becoming 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 following physical and chemical changes (certainty of occurring is in parentheses):

- Increased air temperature (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 flood frequency and intensity (moderate certainty)
- Higher summer stream temperatures (moderate certainty)
- Higher sea level (high certainty)
- Higher ocean temperatures (high certainty)
- Intensified upwelling (moderate certainty)
- Delayed spring transition (moderate certainty)
- Increased ocean acidity (high certainty)

These changes will affect human and other biological ecosystems within the cumulative effects analysis area (Ecology 2012a; Mauger et al. 2015; NWFSC 2015). Changes to biological organisms and their habitats are likely to include shifts in timing of life history events, changes in growth and development rates, changes in habitat and ecosystem structure, and 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 changes will have multiple effects. Expected effects include:

- Overtaxing of storm water 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 damages 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., for irrigated agriculture, human consumption, and habitat for fish)
- Shifts in irrigation and growing seasons

- Changes in plant, fish, and wildlife species' distributions and increased 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 the continental shelves off Oregon and Washington (Halpern et al. 2009).

Several studies note that similar changes are expected to occur in British Columbia. For example, climate change effects in Georgia Strait are expected to include warming of marine waters (Littell et al. 2009) and fresh waters (Perry 2009), and changes in river flow patterns from snow-melt-dominated conditions to rainfall-dominated conditions. Examples of the effects of climate change on human populations include loss of agricultural land because of inundation by rising sea levels, increases in storm intensity duration and frequency, salinization of municipal water intakes, and increases in the risk of tidal flat erosion and dike breaching and flooding (Natural Resources Canada [NRC] 2014).

5.4.2 Development

Future human population growth in the Seattle and Vancouver areas, and the areas between them, is expected to continue over the next 15 years. For example, the number of people in the Vancouver area is expected to grow by over 35,000 residents per year (Metro Vancouver 2013), and in the Puget Sound area by 40,000 per year (Puget Sound Regional Council 2013). 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, increases in withdrawals of fresh water to meet increasing food and resource requirements, and increases in energy demands. Although the rate of urban sprawl has been decreasing in comparison to previous increases in the late 1900s (Puget Sound Regional Council 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, both the United States and Canada have Federal environmental protection agencies and Federal laws, regulations, and policies that are designed to conserve each nation's air, water, and land resources. Regulatory processes involve agency review, approval, and permitting of development actions. Regulatory examples include the ESA in the United States and the Species at Risk Act in Canada. Other examples include the Navigable Waters regulations of the Clean Water Act in the United States, and the Navigable Waters Protection Act in Canada. In the United States, aquaculture facilities (such as enclosed facilities for raising and selling fish, shellfish [including geoducks], and aquatic plants) are regulated by Washington State. In Canada, aquaculture facilities are regulated by British Columbia Department of Fisheries, and Fisheries and Oceans Canada. These environmental laws will continue to require agency review and approval of proposed activities.

In addition to Federal laws and processes, state and provincial laws, regulations, and guidelines will help decrease the effects of future commercial, industrial, and residential development on natural ecosystems. In Washington State, various habitat conservation plans (HCPs) have been implemented, such as the Washington Department of Natural Resources (DNR) Forest Practices HCP (DNR 2005), and other HCPs are in development (e.g., DNR Aquatic Lands HCP and WDFW Wildlife Areas HCP). These plans will provide long-term, landscape-based protection of federally listed and non-listed species considered at risk of extinction in Washington's private and state forested lands. 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 Revised Code of Washington), which requires local land use planning and development of regulations, including identification and protection of critical areas from future development.

Although the Province of British Columbia does not have comparable growth management laws and regulations for future development, the province reviews and approves future development primarily through its Environmental Assessment Act (which is separate from the Federal Canadian Environmental Assessment Act) and other laws and regulations (such as the Environment and Land Use Act, Environmental Management Act, Forest Act, Water Act, Water Protection Act, Wildlife Act, Fisheries Act, Shorelines Management Act, and Fish Protection Act). These provincial and state regulations will continue to help decrease habitat fragmentation, avoid residential development and urban sprawl in sensitive habitat and ecosystems, and decrease contamination to air, lands, and waterways.

In Washington, local land use laws, regulations, and policies will also help protect the natural environment from future development effects. For example, the Puget Sound Regional Council (PSRC) developed Vision 2040 to identify goals that support preservation and restoration of the natural environment ongoing 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. These objectives also include preserving open space, focusing on sustainable development, and 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, such as local sensitive areas acts and shoreline protection acts.

In lower British Columbia, local zoning and development laws will help to protect open space from future development. The Greater Vancouver Regional District designates Green Zones to protect natural land assets (Greater Vancouver Regional District 2005). In addition, the Fraser River Estuary Management Plan was developed by a partnership of agencies and serves as a policy guide for municipalities and other agencies with jurisdiction or interest in the Fraser River estuary (Fraser River Estuary Management Program 2012). In ecologically sensitive areas, this plan is focused on protecting critical fish and wildlife functions. In addition, municipalities in British Columbia have community plans with policies and guidelines related to land use, development, services, amenities, and infrastructure related to future development (NRC 2014). The plans identify environmentally sensitive areas where future development is limited to protect environmental attributes.

In summary, in the Washington and British Columbia portions of the cumulative effects analysis area, Federal, state, and local laws, regulations, and policies will be applied with the intent to better enforce environmental protection for proposed future project developments. 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, it is unlikely that all environmental goals and objectives will be successfully met by such processes. 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 as 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 create a healthy environment and sustainable ecosystem (PSRC 2009; BCMWLAP 2002). United States Federal agencies and organizations are expected to continue to support habitat protection and restoration initiatives/processes in Puget Sound, including projects such as the Puget

Sound Nearshore Ecosystem Restoration Project (Puget Sound Nearshore Ecosystem Restoration Partnership 2013), which is a partnership between the U.S. Army Corps of Engineers and WDFW for the purpose of identifying ecosystem degradation, formulating solutions, and recommending actions and projects to help restore Puget Sound. The Puget Sound Partnership (formerly the Shared Strategy for Puget Sound) 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-government 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 2011a). However, based on a recent review of the implementation of the Puget Sound Chinook salmon recovery plan (NMFS 2011b), habitat continues to decline faster than it has been restored, and habitat protection tools currently in place continue to need improvement.

Federal Canadian funding for habitat restoration includes several ongoing and expected future funded programs supported by Environment Canada. These projects regularly provide annual funding for habitat restoration and include:

- B.C. Hydro Bridge Coastal Fish and Wildlife Restoration Program (designed to fund projects to restore fish and wildlife populations and habitats in watersheds impacted by hydroelectric generation facilities)
- Habitat Conservation Trust Fund (includes funds for habitat enhancement and restoration)
- Public Conservation Assistance Fund (with objectives similar to the Habitat Conservation Trust Fund)
- EcoAction Community Funding Program (with several objectives that include habitat enhancement and rehabilitation)

It is expected that Washington State will continue to support habitat restoration 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 a healthy Puget Sound. 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 2012). 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 the natural functions of the ecosystem and support sustainable economic growth. Local community efforts, such as smaller community habitat restoration and protection efforts, will help protect sensitive areas in Puget Sound.

In British Columbia, the provincial Watershed Restoration Program under Forest Renewal British Columbia will continue to restore the productive capacity of fisheries, and forest and aquatic resources that have been impacted by past forest practices. The Watershed Restoration Program hastens the recovery of degraded environmental resources in logged watersheds by identifying the needs for proposed restoration projects and by designing and implementing restoration that re-establishes conditions more similar to those found in watersheds that are not degraded. Other provincial and local habitat restoration initiatives will be continued, including the Salmon Habitat Restoration Program, which has historically been supported by the Canadian Federal government, but is now supported by the provincial and local governments.

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, provincial, and local programs ~~will~~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 ~~will help to counterbalance~~ 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.~~, which have previously 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).~~

5.4.4 Hatchery Production

It is likely that the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the analysis area will change over time. These changes are likely to reduce effects to natural-origin salmon and steelhead such as genetic effects, 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 to natural-origin salmon and steelhead would be 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; when available, incorporation of new research results and improved best management practices for hatchery operations; decreased production levels; or termination of programs. Similar changes would be 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. For steelhead, under WDFW's Statewide Steelhead Management Plan (WDFW 2008), Wild Steelhead Management Zones (or wild stock gene banks) are in the process of being identified and implemented in at least three Puget Sound watersheds to promote the recovery of steelhead populations (see http://wdfw.wa.gov/conservation/fisheries/steelhead/gene_bank/). In those watersheds, to protect natural-origin steelhead from the effects of steelhead hatchery programs, releases of hatchery-origin steelhead would not occur.

5.4.5 Fisheries

It is likely that the salmon and steelhead fisheries in the analysis area will change over time. These changes are likely to reduce effects to natural-origin salmon and steelhead listed under the ESA. For example, effects to natural-origin salmon and steelhead would be expected to decrease over time to the extent that fisheries management programs continue to be reviewed and approved by NMFS under the ESA, as evidenced by the beneficial changes to programs that have thus far undergone ESA review. 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 recovery of listed fish species occurs or species abundance becomes sufficiently large, 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. The resources for which cumulative effects are described are: water quantity and quality, salmon and steelhead, other fish species, wildlife – Southern Resident killer whale, socioeconomics, and environmental justice.

5.5.1 Water Quantity and Quality

Subsection 3.1, Water Quantity, describes the baseline conditions of water quantity. Water quality information for the analysis area is described in Subsection 3.6.1, Water Quality, in the PS Hatcheries DEIS (NMFS 2014a). These conditions are the result of many years of climate change, development, and habitat restoration, and operation of hatchery programs. The effects of the alternatives on water quantity are described in Subsection 4.1, Water Quantity. As described in Subsection 1.6, Scoping and Relevant Issues, and consistent with Subsection 4.6.3, Water Quality, in the PS Hatcheries DEIS (NMFS 2014a), and draft environmental assessments for salmon hatchery programs in the Dungeness River (80 Fed. Reg. 15985, March 26, 2015), effects of hatchery programs on water quality would be expected to be negligible. 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. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on water quantity and water 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 affecting water quality by increasing water temperatures and affect water quantity by changing seasonality and magnitude of river flows. Although existing regulations are intended to help protect water quality and quantity from effects related to future development, 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. Changes in types of hatchery programs over time are unlikely to improve water quality and quantity, because water use would be similar regardless of program type. However, reductions in hatchery production or terminations of programs could improve water quality and quantity to the extent that less water is used in hatchery operations. Fisheries on salmon and steelhead would not be expected to affect water quality or quantity. Overall, cumulative effects of climate change, development, and hatchery production on water quality and quantity are more likely to reduce water quantity than 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 quality and quantity, although this is the goal of many of the restoration programs.

In summary, cumulative effects from climate change, development, habitat restoration, and hatchery production would likely impact water quality (particularly water temperature changes) and water quantity (increased demand on limited water supplies) in the analysis area more than that described in Subsection 4.1, Water Quantity, and as described in Subsection 4.6.3, Water Quality, in the PS Hatcheries DEIS (NMFS 2014a) under all alternatives. None of the alternatives 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. Future actions are described in Subsection 5.4, Future Actions and Conditions. This subsection describes cumulative effects on salmon and steelhead that may occur as a result of implementing any of the alternatives at the same time as other future actions. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on 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 36 percent of historical run sizes in British Columbia, and 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. This subsection provides brief overviews of the effects of climate changes, development, habitat restoration, hatchery production, and fisheries on salmon and steelhead.

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). Cumulative effects from climate change, particularly changes in streamflow and water temperatures, would likely impact hatchery-origin and natural-origin salmon and steelhead life stages in various ways as described below and shown in Table 18. 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. 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 streamflow and water temperature), the effects to 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 freshwater 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).

~~However, under all alternatives, effects to salmon and steelhead from density-dependent impacts would be undetectable, because the numbers of early winter steelhead released would be unsubstantial~~.

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 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).

Table 18. 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 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), ~~and~~ Beechie et al. (2013), and Wade et al. (2013).

The primary cause of these continuing 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 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). However, habitat restoration alone will not substantially increase survival and abundance of salmon and steelhead. In addition, habitat restoration is dependent on continued funding, which is difficult to predict when economic recessions occur or governments experience deficits. Benefits from habitat restoration are expected to affect salmon and steelhead survival similarly under all alternatives.

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.

In addition to hatchery production of salmon and steelhead in Puget Sound (described in Subsection 3.2, Salmon and Steelhead), hatchery production and salmon aquaculture also occur in the Canadian portion of the cumulative effects analysis area. The Canadian Salmonid Enhancement Program uses hatcheries, along with other strategies, to conserve and rebuild populations of natural-origin salmon and to provide fishing opportunities for Canadians (MacKinlay et al. 2004). In 2002, these hatcheries raised 173 million salmon, steelhead, and trout (Chinook salmon, 30 percent; chum salmon, 42 percent; coho salmon, 11 percent; pink salmon, 10 percent; sockeye salmon, 7 percent; steelhead, less than 1 percent; and cutthroat trout, less than 1 percent). Total time in hatcheries for these fish is 10 months or less with subsequent release into freshwater or marine environments. Releases are from 18 major hatcheries, 21 community hatcheries, and 16 public involvement or educational hatcheries. Releases in 2009 were 300 million fish. The majority of the 2009 fish released were sockeye salmon (about half the fish released) followed by chum salmon, Chinook salmon, pink salmon, coho salmon, steelhead, and cutthroat trout (Sandher et al. 2010). Aquaculture operations also occur in British Columbia where salmon are raised in marine pens to adulthood with subsequent seafood processing and no fish releases into the freshwater or marine environment. These aquaculture operations raise almost exclusively Atlantic salmon. Hatchery production in the Canadian portion of the cumulative effects area may increase density-dependent impacts on Puget Sound salmon stocks that intermingle with Canadian stocks. In addition, salmon aquaculture in the Canadian portion of the cumulative effects analysis area may increase disease risks for Puget Sound salmon stocks. Puget Sound steelhead would likely be less impacted by hatchery production and salmon aquaculture in Canada when compared to Puget Sound salmon because they out-migrate at a large size and move to sea more directly, therefore intermingling less with Canadian salmon and steelhead stocks.

The effects to 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, Genetic Risks; Appendix B, Genetic effects analysis of early winter steelhead programs proposed for the Nooksack, Stillaguamish, Dungeness, Skykomish, and Snoqualmie River basins of Washington; Subsection 2.1.3, Genetics, in Appendix B of the PS Hatcheries DEIS [NMFS 2014a]) may occur through changes such as increased use of integrated hatchery programs, application of new research results that lead to improved best management practices, and reductions in production levels. For example, the hatchery co-managers recently decided to reduce the size of their summer steelhead hatchery program in the Skykomish River basin (Unsworth 2016), and that will further reduce genetic risks to Puget Sound steelhead under all alternatives. Over time, these changes would also be expected to reduce the ecological risks of competition and predation. In general, continued hatchery releases within the Salish Sea, along with other observed environmental trends as described in the following subsections, would affect continued long-term viability of natural-origin salmon and steelhead.

In summary, to the extent aquatic habitat will continue to degrade over time under all alternatives, the abundance and productivity of natural-origin salmon and steelhead populations may be reduced. Hatchery-origin salmon and steelhead may be similarly affected. In addition, effects to 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 would affect the overall trend in cumulative effects on salmon and steelhead, Alternative 1 and Alternative 4 could help mitigate negative effects on steelhead. That is~~,~~ because under Alternative 1 hatchery programs would be terminated, and under Alternative 4 the type of program would change to use of a local, native broodstock (unlike under Alternative 2,~~ and~~ Alternative 3, and Alternative 5). These hatchery programs could be used to reduce the extinction risk of natural-origin populations resulting from cumulative effects such as habitat degradation in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins.

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. 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. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on fish species other than salmon and steelhead.

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 plants that may, over time, out-compete native aquatic plants that provide important habitat 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.

In summary, cumulative effects from climate change, development, habitat restoration, and hatchery production on other fish species, including bull trout, would likely result in a decrease in the abundance of those fish species in the analysis area. Cumulative effects on fish species that compete, 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 would affect the overall trend in cumulative effects on other fish species, including bull trout, because the range of production levels under the alternatives (e.g., from 0 to 620,000 early winter steelhead hatchery-origin smolts) would be a small fraction of the total salmon and steelhead in the analysis area that these other fish species could compete with, prey on, or be prey items for.

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, and hatchery production. The effects of the alternatives on wildlife in Puget Sound are described in Subsection 4.4, Wildlife – Southern Resident Killer Whale. Future actions for the overall cumulative effects analysis area are described in Subsection 5.4, Future Actions and Conditions. This subsection considers potential effects that may occur as a result of implementing any one of the alternatives at the same time as other anticipated actions. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on wildlife.

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 to Southern Resident killer whales may include changes in distribution in response to changes in the abundance and distribution of their food supply, decreases in abundance, and decreases in reproductive success compared to that described in Subsection 4.4, Wildlife – Southern Resident Killer Whale. Effects to 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 may decrease the prey base available for wildlife species (Southern Resident killer whales) that use salmon and steelhead as a food source.

In summary, 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. However, none of the alternatives would affect the overall trend in cumulative effects on wildlife because the range of production levels under the alternatives (e.g., from 0 to 620,000 early winter hatchery-origin steelhead smolts) would be a small fraction of the total number of prey items for wildlife in the analysis area.

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, and hatchery production. The expected effects of the alternatives on socioeconomics are described in Subsection 4.5, Socioeconomics. Future actions are described in Subsection 5.4, Future Actions and Conditions. This subsection considers potential effects that may occur as a result of implementing any one of the alternatives at the same time as other anticipated actions. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on socioeconomic resources.

Although unquantifiable, climate change and development actions, 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 angler expenditure and economic revenue relative to conditions considered in Subsection 4.5, Socioeconomics. Likewise, it may reduce the number of 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.

As discussed in Subsection 5.4.4, Hatchery Production, and Subsection 5.4.5, Fisheries, changes in hatchery programs and fisheries may occur over time. Changes in hatchery programs may affect the socioeconomic effects from hatchery production of salmon and steelhead. For example, reductions in hatchery production or terminations of hatchery programs may decrease the number of fish available for harvest, decrease associated angler expenditures and revenues generated from fishing, and reduce the number of steelhead available to tribal members.

In summary, it is likely that cumulative effects from climate change, development, and hatchery production would decrease the number of fish available for harvest and reduce angler expenditure and economic revenue relative to conditions considered in Subsection 4.5, Socioeconomics. However, none of the alternatives would affect the overall trend in cumulative effects on socioeconomics because the range of production levels under the alternatives (e.g., from 0 to 620,000 early winter hatchery-origin steelhead smolts) would result in a small fraction of the total harvestable salmon and steelhead in the analysis area, and, therefore, comprise a small fraction of the overall economic benefits derived from salmon and steelhead harvest in the analysis area

5.5.6 Environmental Justice

Subsection 3.6, Environmental Justice, describes environmental justice communities in the analysis area. Subsection 3.6, Environmental Justice, also describes methods for identifying environmental justice user groups and communities of concern. 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. Future actions are described in Subsection 5.4, Future Actions and Conditions. This subsection considers potential effects that may occur as a result of implementing any one of the alternatives at the same time as other anticipated actions. This subsection discusses the incremental impacts of the alternatives in addition to past, present, and reasonably foreseeable future actions (i.e., cumulative effects) on environmental justice user groups and communities of concern.

Climate change and development actions, and 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 fishing opportunity 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 or recreational harvest.

As discussed in Subsection 5.4.4, Hatchery Production, and Subsection 5.4.5, Fisheries, changes in hatchery programs and fisheries may occur over time. Changes in hatchery programs may affect the number of salmon and steelhead available for harvest by environmental justice communities.

In summary, it is likely that cumulative effects from climate change, development, and hatchery production would decrease the number of fish available for harvest relative to conditions considered in Subsection 4.6, Environmental Justice. However, none of the alternatives would affect the overall trend in cumulative effects on environmental justice because the range of production levels under the alternatives (e.g., from 0 to 620,000 steelhead smolts) would result in a small fraction of the total harvestable salmon and steelhead in the analysis area available to environmental justice communities.

5.6 Summary of Effects

Table 19 summarizes the combined effects of past, present, and reasonably foreseeable actions, other than the Proposed Action and alternatives (summarized above), affecting the environmental resources reviewed in this EIS, affected by climate change, human development, habitat restoration, and hatchery production.

Table 20 summarizes the conclusions made above on the impacts of past, present, and reasonably foreseeable actions when combined with the impacts of the Proposed Action. Definitions for effects terms are the same as described in Subsection 3, Affected Environment, and Subsection 4, Environmental Consequences. The relative magnitude and direction of impacts is 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 19. 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	Reasonable Foreseeable Future Actions	Past, Present, and Reasonably Foreseeable Future Actions
Water Quantity	Negligible to low negative due to water withdrawals from human development	Negligible to low negative	Low negative	Low negative
Salmon and Steelhead	Moderate to high negative due to human development, past fishery, hatcheries, and habitat management practices	Mixed (negligible to moderate negative, to low positive) due to ESA compliance and improved fishery, hatcheries, habitat management practices, and habitat restoration, depending on population	Mixed (moderate negative to low positive), depending on population	Mixed (moderate negative to low positive), depending on population
Other Fish Species	Mixed (negligible to low negative, to negligible positive) depending on species, due to human development, past fishery, hatcheries, and habitat management practices	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 habitat degradation and hatchery-origin salmon and steelhead as a food source	Low positive due to ESA compliance	Negligible to low positive	Low positive
Socioeconomics	Moderate positive from benefits to recreational fisheries and tribal fisheries, although some have been reduced in recent years as numbers of fish available to harvest have declined	Low positive due to declines in harvest opportunities	Low positive	Low positive
Environmental Justice	Low to moderate negative due to reductions in fish available for use by communities of concern and populations of concern such as treaty Indian tribes	Low negative to low positive	Negligible negative	Low negative

Table 20. Summary of the cumulative effects of the Proposed Action.

Affected Resource	Baseline	Past, Present, and Reasonably Foreseeable Future Actions	Proposed Action	Cumulative Effects of the Proposed Action
Water Quantity	Mixed (negligible negative to negligible positive)	Low negative	Negligible negative	None
Salmon and Steelhead	Mixed (negligible to moderate negative, to low positive) due to ESA compliance and improved fishery, hatchery, habitat management practices, and habitat restoration, depending on population	Mixed (moderate negative to low positive), depending on population	Negligible negative	None
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	None
Wildlife – Southern Resident Killer Whale	Low positive due to ESA compliance	Low positive	Negligible positive	None
Socioeconomics	Moderate positive	Low positive	Moderate positive	None
Environmental Justice	Low negative to low positive	Low negative	Negligible positive	None

Chapter 6

6 REFERENCES

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Chapter 7

7 DISTRIBUTION LIST

Federal and State Agencies

Council of Environmental Quality
Department of Fisheries and Oceans, Government of Canada
NMFS Northwest Fisheries Science Center
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, Portland Oregon Office
U.S. Fish and Wildlife Service, Western Washington Office
Washington Governor's Salmon Recovery Office
Washington Department of Fish and Wildlife, Olympia Office
Puget Sound Partnership

Elected Officials

Washington Governor's Office
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

Anacortes Public Library
Clallam Bay Library
Everett Public Library
Jefferson County Library
King County Library System, Bellevue
Kitsap Regional Library
Mount Vernon City Library
North Olympic Library System, Main Library, Port Angeles
Olympia Timberland Library
Pierce County Library
Port Orchard Library
Seattle Public Library, Main Library
Sno-Isle Libraries
Tacoma Public Library
Washington State Library
Whatcom County 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 on genetics, James Dixon on socioeconomics)

- NMFS Protected Resources Division (Lynne Barre and Teresa Mongillo on Southern Resident killer whales)
- NWIFC (Chris James on hatchery plans)
- WDFW (Jim Scott, Kelly Cunningham, and Brian Missildine on hatchery production; Teresa Scott and Beata Dymowska on water quantity; Robert Leland and Eric Kraig on steelhead harvest)

During development of the EIS, NMFS also consulted with the following tribes, organizations, and individuals:

- Jamestown S'Klallam Tribe (Scott Chitwood on tribal resources)
- Lummi Nation (Alan Chapman, Randy Kinley, and Merle Jefferson on tribal resources)
- Muckleshoot Indian Tribe (Isabel Tinoco on tribal resources)
- Nooksack Indian Tribe (Ned Currance on tribal resources)
- Sauk-Suiattle Indian Tribe (Janice Mabee on tribal resources)
- Skagit System Cooperative (Lorraine Loomis on tribal resources)
- Stillaguamish Tribe (Jason Griffith and Kate Konoski on tribal resources)
- Tulalip Tribes (Terry Williams and 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

Table A-1. Chinook 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]	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	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	4,000,000	Samish Hatchery	Samish River RM 10.5
Chinook	Georgia Strait	San Juan Islands (Orcas)	Glenwood Springs Hatchery (January 2013)	Green R. lineage (out-of-ESU)	Summer/ Fall	Isolated harvest	Harvest augmentation	Long Live The Kings	Subyearling/ July	550,000	Glenwood Springs Hatchery	Eastsound, Orcas Island (One HGMP)

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	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	Indicactor 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
Chinook	Whidbey Basin	Snohomish	Bernie Kai-Kai Gobin Salmon Hatchery, Tulalip spring Chinook (March 2004)	Cascade	Spring	Isolated harvest	Harvest augmentation	Tulalip Tribes	Yearling/ March	40,000	Bernie Kai-Kai Gobin Salmon Hatchery	Tulalip Bay, Port Susan
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

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	**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	Websters Rearing Ponds
									Subyearling/ May	1,600,000	Grovers Creek Hatchery/Gorst Creek Rearing Ponds	Gorst Creek Rearing Pond

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	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
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 ~~fingerling~~ 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

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	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	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
-	-	-	**White River Hatchery (spring Chinook)**(December 2014**)**	-	-	-	-	-	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

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)
												Twenty-eight Mile Creek.
Chinook	Central/ South Sound	Carr Inlet/South Sound	**Minter Creek/ Hupp Springs Hatchery White River spring Chinook** (2015-pending)	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 Hatchery fall Chinook (May 2013)	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
									Yearlings/ March-April	120,000	Hupp Springs Hatchery	Hupp Springs Hatchery on Minter Creek RM 3.0, 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** (September 2014)	Nisqually	Fall	Isolated harvest	Harvest augmentation	Nisqually Tribe	Subyearling/ May-June	3,500,000	Clear Creek Hatchery	Clear Creek, tributary to Nisqually River at RM 6.3

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)
										600,000	Kalama Creek Hatchery	Kalama Creek, tributary to Nisqually River at RM 9.2
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
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

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)
												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

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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~~July 2014~~)	Chambers Ck lineage (out-of-DPS)	Winter	Isolated harvest	Harvest augmentation	WDFW	Yearling/ April-May	140,000 ~~185,000~~	Reiter Ponds	Reiter Pond at Skykomish River RM 46
									Yearling/ April-May	27,600 ~~71,000~~	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 (draft June 2015)	Skamania Hatchery-lineage (out-of-DPS)	Summer	Isolated harvest	Harvest augmentation	WDFW	Yearling/ April	30,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33.5
									Yearling/ April	20,000	Icy Creek Pond	Icy Creek, tributary to the Green River at RM 48.3
Steelhead	Northern Cascades	Green	**Green River Native Winter (late) Steelhead** (July 2014)	Green River	Winter	Integrated recovery	Conservation	WDFW	Yearling/ May	18,000	Icy Creek Pond	Icy Creek, tributary to the Green River 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	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/ May	15,000	Flaming Geyser (Pond)	Flaming Geyser Park, Crystal Creek, tributary to the Green River at RM 44.3
									Yearling/ May	17,000	Palmer Ponds	Palmer Ponds, Green River RM 56.1
									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 (**September 2006**)**	White River	Winter	Integrated recovery	Conservation	Puyallup Indian Tribe and Muckleshoot Indian Tribe w/ WDFW	Yearling/ May	35,000	Diru Creek Hatchery and White River Hatchery	White River RM 24.3, which is tributary to the Puyallup River at RM 10.1

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	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		Eastside Hood Canal Tributaries					Yearlings/ April-May	7,400	LLTK Lilliwaup Hatchery	Dewatto River
									Adults/ March-April	253		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	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 (August 2015)	Nooksack	Normal-timed	Isolated harvest	Harvest augmentation	Lummi Indian Nation	Yearling/ May-June	2,000,000	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 (August 2015)	Nooksack	Normal-timed	Isolated harvest	Harvest augmentation	Lummi Indian Nation	Yearling/ April-May	2,000,000	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
						Integrated Harvest		WDFW	Yearling/ May	600,000	Soos Creek Hatchery	Soos Creek RM 0.8, tributary to the Green River at RM 33.5
Coho	Central/South Sound	Green	Soos Creek Coho Program (July 2014)	Green	Normal-timed	Isolated harvest	Harvest augmentation	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

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	Keta Creek Complex (December 2014)	Green	Normal-timed	Integrated Harvest	Harvest augmentation	Muckleshoot Indian Tribe	Yearling/ May	500,000	Crisp Creek Ponds	Crisp Creek RM 1.1 Green R. tributary at RM 40.1
										500,000	Elliot Bay Netpens	Elliot Bay, Puget Sound
										50,000	Supplementation site	TBD in Green River watershed
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 (June 2013)	Puyallup (Voights Creek Hatchery)	Normal-timed	Integrated harvest	Harvest augmentation	WDFW	Yearling/ April,May	780,000	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 (March 2003)	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

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)
									Yearling/ May	100,000	Voights Creek Hatchery/ Puyallup Tribal Hatchery	Rushingwater Acclimation Pond, RM 0.5 on Rushingwater Creek, trib to Mowich River at RM 1.1
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
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	Nisqually	Clear Creek Hatchery Fall Coho (April 2003)	Central/South Sound mix	Normal-timed	Isolated harvest	Harvest augmentation	Nisqually Tribe	Yearling/ April	?	Clear Creek Hatchery	Clear Creek, tributary to Nisqually River at RM 6.3
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

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 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.

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	34,000,000	Cedar River Hatchery	Cedar River RM 21.7, 13.5, and 2.1

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 (May 2013)	Nooksack	Fall	Integrated harvest	Harvest augmentation	Lummi Indian Nation/ WDFW	Fed fry/ April-May	1,000,000	Lummi Bay Complex, 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 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
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

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	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	?	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	?	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
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

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. 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
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.

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 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.

APPENDIX B

Genetic effects analysis of early winter steelhead programs proposed for the Nooksack, Stillaguamish, Dungeness, Skykomish, and Snoqualmie River Basins of Washington

Anadromous Production and Inland Fisheries Program
Sustainable Fisheries Division
NMFS West Coast Region
October 13, 2015

February 21, 2016 Revision

This revision of the appendix includes some updated data and analyses. It replaces the version that was appended to the draft EIS. For ease of readability, edits are not shown in redline/strikeout format.

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PREFACE

This appendix to the final environmental impact statement (EIS) on early winter steelhead hatchery programs in Puget Sound has been revised with updated data and analysis from the version that was appended to the draft EIS. For ease of readability, edits to the previous version are not shown in redline/strikeout format.

INTRODUCTION

The hatchery programs under consideration in the Nooksack (WDFW 2014b), Stillaguamish (WDFW 2014e), Dungeness (WDFW 2014a), Skykomish (Unsworth 2016; WDFW 2014c; WDFW 2016), and Snoqualmie (WDFW 2014d) basins are isolated harvest programs that release fish that are not included in the Puget Sound steelhead DPS, and do not contribute to the conservation or recovery of the DPS. The program operators will use only early winter steelhead[1] (EWS) produced by the programs (identified by early return timing and presence of an adipose fin clip mark) as broodstock, and no natural-origin steelhead will be collected and spawned. The intent of management of these programs is to have few returning fish in excess of broodstock needs escape to spawn in the wild. Those that do spawn in the wild are expected to have low reproductive success relative to the natural-origin fish because they spawn earlier than natural-origin fish, and thus are presumed to spawn under non-optimal conditions. They may also be less successful than natural-origin fish due to other aspects of domestication. To the extent they do reproduce and contribute to the next generation of natural-origin fish, however, they pose genetic risks to the population. In this section, we analyze the risks posed by this gene flow. NMFS considers three areas of effects caused by gene flow from hatchery-origin fish: within-population diversity, outbreeding effects, and hatchery-influenced selection.

This appendix evaluates genetic effects from recent past practices (e.g., past 5-10 years) of early winter steelhead hatchery programs, and also evaluates projected effects from programs under the most recently submitted HGMPs (i.e., WDFW 2016).

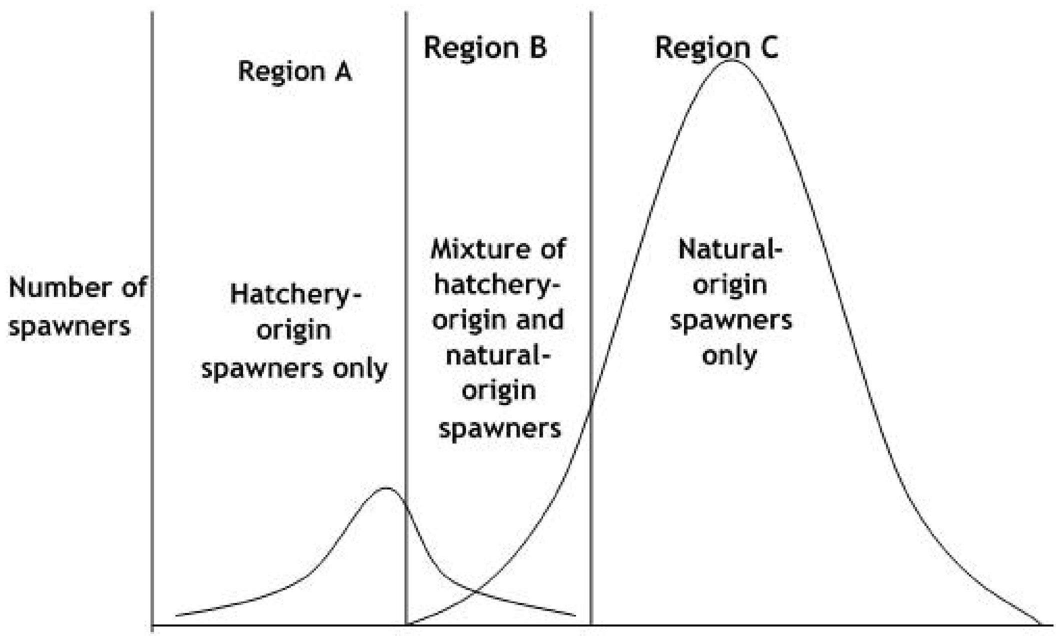
1. WITHIN-POPULATION DIVERSITY EFFECTS

Risk to within-population diversity is much less of a concern in isolated programs such as EWS than in integrated programs, so we will deal with this risk briefly. Within-population diversity is influenced strongly by the effective size of the population. Effective size depression is generally a concern only if the relative abundance of hatchery-origin fish on the spawning grounds far exceeds that of natural-origin

[1] Early winter steelhead are hatchery-origin steelhead of Chambers Creek stock origin.

fish, so that a disproportionate share of the progeny come from a small number of hatchery-origin parents (Ryman et al. 1995). We do not expect this to be the case with the five proposed programs. An additional potential concern is that diversity in the natural-origin population could be lowered by gene flow from a hatchery population with a lower background level of diversity. This is not the case with these programs: the background levels of genetic diversity are essentially identical in the hatchery-origin and natural-origin steelhead populations (Warheit 2014a). In general, we expect the risk posed by the EWS programs to within-population diversity to be negligible.

However, a concern that has been raised in connection with these isolated steelhead programs is that, due to the low expected reproductive success of early winter steelhead spawning in the wild, the reproductive potential of natural-origin fish that spawn with hatchery-origin fish would be reduced or wasted. Reductions in the reproductive output of these natural-origin fish thus reduces the size of the spawning population and therefore the genetically effective size of the population. Figure B-1 is a generalized schematic of the expected distribution of hatchery-origin and natural-origin spawners over time.



The Figure

Figure B-1. Schematic of temporal spawning overlap between early winter hatchery steelhead and natural-origin winter steelhead. Shape, sizes and placement of curves is conceptual and is not meant to represent any specific situation (Scott and Gill 2008, Fig. 4-7).

Although the difference varies from basin to basin, EWS have an earlier spawn timing than natural-origin Puget Sound winter steelhead (Table 3 in Myers et al. 2015).This means there will be a time during the spawning season when hatchery-origin steelhead can only spawn with other hatchery-origin steelhead

(Region A), an overlap period when hatchery-origin and natural-origin steelhead can spawn amongst themselves or with each other (Region B), and a period when natural-origin steelhead can spawn only with natural-origin steelhead (Region C). Assuming random mating[2], the expected proportion of different mating types can easily be determined. In this case, since the only matings that are of interest are those that occur in Region B, and of those, only the matings in which natural-origin fish mate with hatchery-origin fish are of interest.

The expected proportion of the natural-origin escapement actually mating with hatchery-origin fish is given by:

$$\frac{pHOS*O_N*O_H}{pHOS*O_H+(1-pHOS)*O_N} \quad (1),$$

where pHOS is the proportion of natural-origin spawners that are of hatchery origin, and O_N and O_H are the proportions of the natural-origin spawners and the hatchery-origin spawners, respectively, that spawn in Region B.

Based on extrapolations from spawning ground observations and return times of hatchery fish to the hatcheries (Hoffmann 2014), the proportion of the natural-origin spawners involved in HxN matings[3] is expected to be very low, at most 1.4% in the Skykomish population (Table B-1). Thus, under the assumption that the reproductive output of a natural-origin fish mating with a hatchery-origin fish is a complete loss, the impact to the population in terms of demographic population size would be less than 1% in three of the programs and under 2% in the others. This loss would be expected to occur repeatedly, but the effects would not be cumulative. In this respect, its demographic impact would be the same as a loss due to harvest or an ecological interaction.

All parameters used in the modeling just presented are subject to uncertainty, as will be discussed in other sections below. We present a simple evaluation of the effects of this uncertainty in Figure B-2, which shows the proportion of natural-origin fish participating in HxN matings as a function of pHOS and overlap. For simplicity, in this analysis we assumed that O_N and O_H were equal (Table B-1). Overlap and pHOS must be considerable before the proportion of natural-origin spawners in HxN matings reaches

[2] Random mating is assumed in a number of basic population genetic models for mathematical simplicity. The models in this section are based on simple population genetic models, and use the random mating assumption for the same reason. Mating dynamics of steelhead and salmon are in fact non-random, but attempting to include all the deviations from random mating would be a major modelling exercise in itself. We assume that the results of our modelling is robust to the typical deviations from random mating found in nature.

[3] The HxN notation indicates matings in which a hatchery-origin male mates with a natural-origin female, and vice versa. HxH indicates matings between hatchery-origin parents, and NxN indicates matings between natural-origin parents.

even 1%, and this proportion has a maximum value of pHOS if overlap is complete (equation 1). This additional analysis reinforces the result that the effect of loss of reproductive capacity due to natural-origin spawners mating with hatchery-origin fish would be small. This would translate to an even smaller percentage decrease in effective size, and a consequent effect on genetic diversity that would be unmeasurably small.

Table B-1. Expected percentage of natural-origin escapement involved in HxN matings for winter steelhead populations affected by EWS releases. Table B-2 provides further details on metrics used in calculations. All values are expressed as percentages.

Metric/Data	Population				
	Nooksack	**Stillaguamish**	**Dungeness**	**Skykomish**	**Snoqualmie**
O_N	6.21	1.25	4.33	1.96	2.10
O_H	8.38	18.41	16.88	27.90	16.88
Max pHOS	5.5	5.1	3.8	14.6	13.5
Expected percentage of natural-origin fish mating with hatchery-origin EWS	0.45	0.55	0.58	1.39	1.17

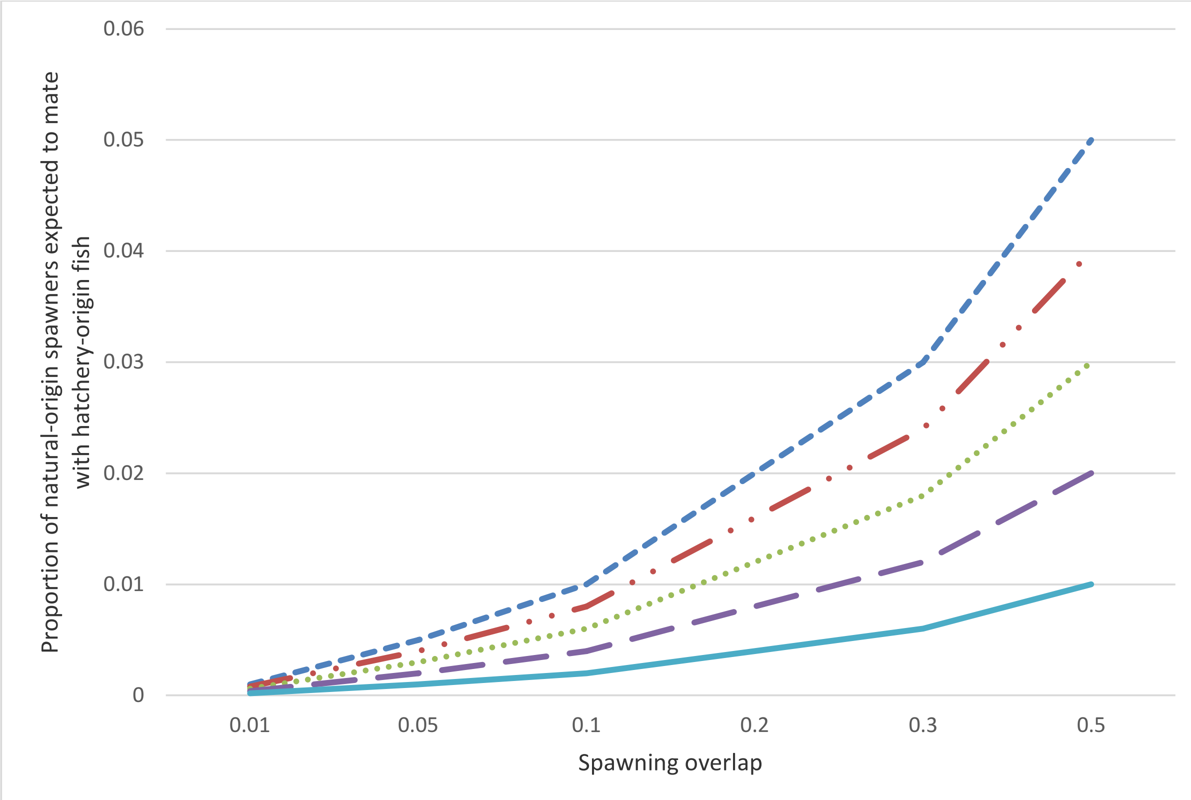


Figure B-2. Proportion of natural-origin fish expected to be involved in HxN matings as a function of pHOS, and proportion of spawners in overlap zone. For simplicity we have assumed that the overlap is the same for natural-origin and hatchery-origin fish; e.g., for the 0.05 level, $O_N=O_H=0.05$. Isopleths represent pHOS=0.1 (small dashes), 0.08 (dots and dashes), 0.06 (dots), 0.04 (large dashes), and 0.02 (solid).

A potential limitation of this "region" approach to analysis of spawning used in the example above is that it assumes that all the spawners are returning anadromous adults. Resident *Oncorhynchus mykiss* (rainbow trout) and precocious residual hatchery juveniles may also be involved, both of which would not have been counted as part of the escapement. McMillan et al. (2007) noted both types of males participating in mating in the later part of the spawning season in an Olympic Peninsula stream. Residual males accounted for less than 1% of the observed mating attempts, and only late in the season. Measurable reproductive success of non-anadromous male *O. mykiss* was noted in another Olympic Peninsula stream that has no hatchery program (Seamons et al. 2004). In Puget Sound, the relative abundance of anadromous and non-anadromous *O. mykiss* is not well known in most streams (Myers et al. 2015), and residualism rates for the programs in the analysis area are not known. A recent meta-analysis of steelhead programs throughout the Pacific Northwest found an average residualism rate of 5.6%, ranging from 0 to 17% (Hausch and Melnychuk 2012). Although residualism per se may have ecological consequences, residual males are not a genetic concern unless they are sexually mature.

Although high rates of precocious maturation in Pacific Northwest steelhead have been reported in the past (e.g., Schmidt and House 1979) before fish cultural methods were developed to control precocious maturation, currently the occurrence of precocious males in WDFW steelhead releases tends to vary from 1 to 5% (Tipping et al. 2003). At these levels, both the demographic and genetic influence of these fish would be insignificant.

2. Outbreeding Effects and Hatchery-influenced Selection Effects

Although we conclude that the effects of EWS on within-population diversity will be negligible, EWS may pose non-negligible risks to natural-origin steelhead populations through outbreeding effects and hatchery-influenced selection. Outbreeding effects are a concern whenever the hatchery-origin and natural-origin fish are from different populations, and this is certainly a case with the early winter hatchery steelhead and the natural-origin populations. In fact, the early winter steelhead are considered so diverged genetically from natural-origin steelhead that they are not considered part of any steelhead DPS (NMFS 2003). The basis of this is the fact that they have been subjected to so many years of intense artificial selection for early smolting, which has resulted not only in smolting predominantly at one year of age, but also earlier spawning time (Crawford 1979). Of all the salmon and steelhead hatchery populations used on the West Coast, NMFS considers the early winter steelhead population the most altered by artificial selection. NMFS has also voiced concerns about the potential genetic risks of EWS programs (Hard et al. 2007; McMillan et al. 2010).

Evaluation of outbreeding effects is very difficult. Under conditions of no selection and no genetic drift, and the best existing management guidance for avoiding out breeding effects, it was the conclusion of the 1995 straying workshop (Grant 1997) that gene flow between populations (measured as immigration rates) should be under 5%. The HSRG (2009) generally recommended that, for primary populations (those of high conservation concern) affected by isolated hatchery programs, the proportion of natural-origin spawners consisting of hatchery-origin fish (pHOS) not exceed 5%, and more recently (HSRG 2014) have suggested that perhaps this level should be reduced. While not addressing them specifically in their guidelines, the HSRG earlier discussed risks posed by highly diverged hatchery populations such as the early winter steelhead, concluding that "…if non-harvested fish spawn naturally, then these isolated programs can impose significant genetic risks to naturally spawning populations. Indeed, any naturally spawning by fish from these broodstocks may be considered unacceptable because of the potential genetic impacts on natural-origin populations" (HSRG 2004, Appendix B). WDFW used the Ford (2002) model to evaluate the hatchery-influenced selection risk of early winter isolated steelhead programs, and concluded they posed less risk than integrated native-stock programs at gene flow levels below 2%, but greater risk at levels above that (Scott and Gill 2008). WDFW's statewide steelhead management plan states that isolated programs will result in average gene flow levels of less than 2% (WDFW 2008).

Some explanation is needed at this point of the relationship between pHOS and gene flow, because the two can easily be confused. Genetic impacts from hatchery programs are caused by gene flow from hatchery fish into the naturally spawning population. Thus, if hatchery-origin fish equal natural-origin fish in reproductive success, pHOS represents the maximum proportionate contribution of hatchery-origin parents to the next generation of natural-origin fish. In the absence of other information, pHOS is an estimate of maximum gene flow on the spawning grounds, and thus is a surrogate for gene flow. Although the EWS-specific modeling by Scott and Gill (2008) used the Ford model, NMFS feels the Ford model may not be a good fit to the situation of EWS spawning in the wild for two reasons. First, highly domesticated steelhead stocks are known to have low fitness in the wild (e.g., Araki et al. 2007; Chilcote et al. 1986), so gene flow is nearly certain to be lower than that predicted by the Ford model. This is the situation that inspired the HSRG (2014) to develop the "effective pHOS" concept. Second, even if it is assumed that the EWS are equal in fitness to the natural-origin fish, the Ford model does not consider the effects on gene flow of partially overlapping spawning distributions, which will decrease the proportion of HxN matings and increase the proportion of HxH matings relative to what it would be with total temporal overlap of hatchery-origin and natural-origin spawners. Focusing attention on gene flow rates rather than pHOS is thus always advisable if feasible, and especially in the case of EWS spawning in the wild, NMFS feels that pHOS levels considerably overestimate gene flow levels.

In discussing gene flow from hatchery programs, it is also important to distinguish the EWS from most other hatchery programs. Although some divergence from natural life history can be expected over time in hatchery programs, the EWS stock represents a situation in which the fish have been subjected to intensive artificial selection over many years for a divergent life history (Crawford 1979). The prospect of gene flow from such highly domesticated stocks seems intuitively risky, as is reflected in the cautionary statement of the HSRG that was cited above. However, studies have only recently begun to compare the relative impact of highly domesticated stocks, such as those considered in this review, and with those that are less domesticated. A modeling effort by Baskett and Waples (2013) demonstrated that the effects of programs using "different" broodstocks could be quite different than those from "similar" programs, and depending on the circumstances, could pose more or less risk. The key element in determining risk level is an understanding of the impact of the gene flow on fitness. This is discussed in the next section.

2.1. Gene Flow and Fitness

In attempting to understand the risks posed by EWS spawning in the wild, three distinctive characteristics of this phenomenon must be considered: 1) the hatchery-origin fish are known to have low reproductive success in the wild relative to natural-origin fish; 2) the hatchery-origin fish comprise a small portion of the spawning population; and 3) a level of temporal isolation exists between hatchery-origin and natural-origin spawners, resulting in hatchery-origin and natural-origin fish mating among themselves at higher levels than expected under random mating. We know of no empirical information that is applicable to the fitness consequences of natural spawning of EWS in this situation. Similarly, we also know of no modelling that adequately simulates the phenomenon of EWS spawning in the wild, although elements of existing models, such as those of Ford (2002) and Baskett and Waples (2013) would be useful in modeling the EWS situation. Therefore, we decided to develop a new model. In developing the model our intent was above all to capture the maximum fitness impact that could be expected from EWS spawning in the wild, while simulating the conditions mentioned above. We also wanted to do this in as simple a model as possible, as every element added to increase mimicry of biological reality can also create parameterization and interpretation complexity.

The new model, "EWS Sim," is fundamentally an individual-based version of the Ford model[4], with selection occurring only at reproduction that also simulates zones of NxN, HxN, and HxH matings. Like the Ford model, EWS Sim tracks phenotypic change due to interbreeding with hatchery fish as a trait subject to stabilizing selection[5]. Fitness of an individual fish is determined by the distance of its phenotype from an optimum Θ, and by the strength of selection. In application, as in the Ford model, the trait under selection is a surrogate for a complex of traits that collectively contribute to fitness, rather than a representation of a specific trait. The model was developed with input and review from geneticists at NMFS' Northwest Fisheries Science Center (NWFSC).

To run EWS Sim, the user inputs key management elements: total number of spawners, pHOS, and overlap of hatchery-origin and natural-origin spawners. The user also inputs two "unknown" values which control the fitness in general, and especially that of the hatchery-origin fish: selection strength and difference between natural and hatchery trait optima. Here we used Ford (2002) for initial guidance. Ford

[4] The Ford model simulates groups of fish; EWS Sim simulates individual fish. This lessens the need for assumptions about phenotypic and fitness distributions.
[5] Stabilizing selection is a form of natural selection in which fitness of individuals decreases as their phenotypes deviate from an optimal value.

used selection strengths of 3σ[6] and 10σ for strong and weak selection, respectively[7], and distances between the two optima ranging from approximately 3σ to 15σ. We used approximately the same range for selection strength, but used a more limited range for the difference between optima. Heritability is also an "unknown" input, but one that has considerably less impact on results than selection strength and difference between optima; here we used 0.25, based on the recommendation of NWFSC geneticists.

Using these input values, EWS Sim then simulates a mating among natural-origin and hatchery-origin fish, with the number or progeny produced per mating determined by the fitness values of the parents. The phenotypic mean of the progeny generation is then compared to the parental generation, and the difference is expressed in in terms of fitness. Two other key outputs are gene flow (the proportion of the naturally produced progeny gene pool from matings involving hatchery fish), and reproductive success of hatchery-origin fish relative to natural-origin fish (RRS). This process is done for a user-specified number of iterations, with results averaged over all iterations.

After some initial exploration of the model, we did a series of simulations (500 iterations each), holding the total number of parental fish constant at 500 and heritability constant at 0.25. The following values were used for other parameters:

1) *pHOS*: 2%, 5%, 8%, 10%, 15%, and 20%
2) overlap: O_H=O_W in both cases, 20% and 40%
3) selection strength (ω) in units of σ : 2, 3, 4, 5, and 10
4) distance between θ_w and θ_H , in units of σ : 3, 4.5, and 6

Our goal in this initial series of runs was to narrow the range of parameter values to combinations that resulted in biologically plausible outcomes, with the goal of finding the relationship between gene flow and fitness loss, and then to examine these cases more carefully. RRS was the sole criterion used for biological plausibility. The low RRS of long-domesticated steelhead hatchery is established in the literature (e.g., Araki et al. 2008); we considered any outcome with an RRS above 0.5 as unrealistic.

[6] σ is the phenotypic standard deviation.

[7] Selection strength values indicate the width of the selection curve, and the smaller the curve width, the stronger the selection.

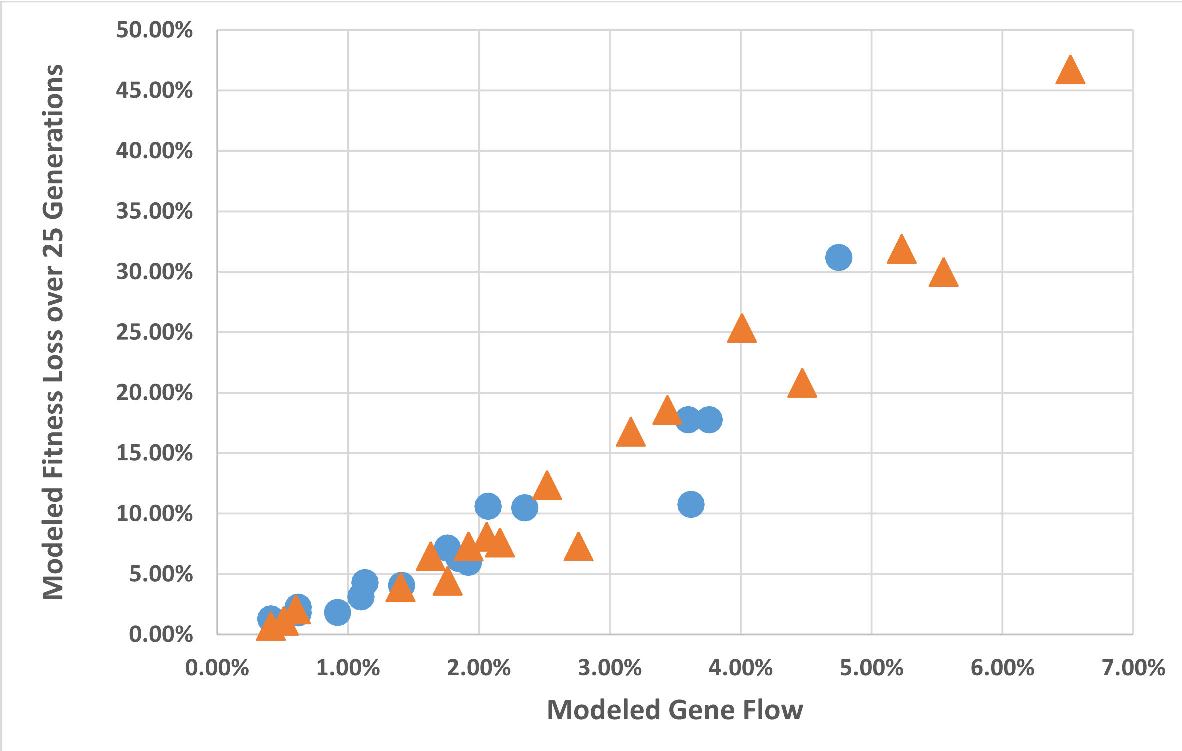


Figure B-3. EWS Sim results: percent fitness loss over 25 generations as a function of gene flow. Circles and triangles denote data points from scenarios in which spawning overlap is 20% or 40%, respectively.

For the plausible subset of scenarios, we used a multiple-generation modification of EWS Sim (100 iterations/scenario) to examine long-term fitness loss, comparing mean fitness after 25 generations to original fitness. We chose 25 generations because it is approximately a century, the default timeline for ESA viability analysis (McElhany et al. 2000). Fitness loss over 25 generations is plotted against the mean gene flow for a single-generation run of the same scenario[8] in the initial set of runs in Figure B-3. The fitness-gene flow relationship is a shallow power curve that can be well approximated by the equation $y = 19.055x^{1.4115}$, where *y* is fitness loss and *x* is gene flow, so expected fitness loss is not a simple linear function of gene flow. The simulations show that gene flow levels of 2% or less should result in no more than 8% fitness loss over 25 generations, but that 4% gene flow could result in three times as much. An important result not apparent from the figure is that the pace of fitness loss changes over time, with the largest decline in the first generation and then the proportionate loss decreasing every generation. The relationship between first-generation loss and cumulative loss over 25 generations can be approximated by an almost identical power curve to that presented above, where *y* is the 25-generation

[8] Because of time constraints, the additional programming required for multiple-generation tracking of variables other than phenotype and fitness have not yet been incorporated into the multiple-generation version of EWS Sim.

loss and x is the first-generation loss[9]. First-generation fitness loss ranged from less than half a percent to nearly 5%; in runs that approximated the gene flow levels expected under the proposed programs (see Sections 2.3.2 and 2.4.1), it was at most less than 1.5%. This phenomenon of fitness loss diminishing in magnitude each generation has an interesting consequence in that if this actually occurs, then populations already subjected to EWS programs (which is the case in the present context), will have already suffered some fitness loss. If so, then into the future the fitness loss 25 generations out will be less than that modeled.

Interestingly, the effect of different levels of spawning overlap seemed to have only a minor effect on fitness loss, especially at low levels of gene flow. Figure B-3 is deceptive in this respect. Although fitness of hatchery-origin spawners (driven by selection strength and difference between optima) was the main determinant of gene flow and thus fitness loss, it is important to note that the higher levels of gene flow were achieved only at the 40% overlap level.

This not to presume, however that EWS Sim is a complete depiction of reality. Like virtually all mathematical models of complex biological processes, EWS Sim is a simplification of reality developed to explore one or more biological phenomena. It incorporates genetic processes as probability distributions, so contains no explicit genetic mechanism. It uses non-overlapping generations, and ignores age structure. It greatly simplifies mating dynamics, and generation of varying numbers of progeny per mating. None of these simplifications can be regarded as out of the ordinary for modelling of this sort, and their consequences to results are likely minor. EWS Sim also does not explicitly consider the consequences of life history variations such as residual males and mating with resident males; we assume they are adequately covered by the spawning overlap parameter. Most importantly, the model assumes that all the poor reproductive behavior of EWS is genetic in origin and causes fitness loss due to stabilizing fecundity selection, which is almost certainly a simplification of the true situation. However, these simplifications likely overestimate the fitness impact of EWS programs, especially in that the upper level of spawning overlap modeled (40% in both directions) allows higher rates of mating of interbreeding between hatchery-origin and natural-origin fish than are thought to be possible under the levels of hatchery releases envisioned in the proposed HGMPs.

The basic result from the EWS Sim runs, that low rates of gene flow can result in relatively minor fitness loss, are consistent with earlier simulations by Ford, who showed that low level gene flow from isolated programs could result in long-term fitnesses of approximately 85% or more of the original level (Ford 2002, Figures 3A and 3B). The EWS Sim results are also consistent with recent HSRG thinking. In the

[9] The relationship becomes less precise as modeled fitness loss increases.

past, discussions about effects of gene flow from hatchery programs have been dominated by the HSRG gene flow guidelines (HSRG 2009; HSRG 2014), which are based on phenotypic means, not directly on fitness. More recently, however, the HSRG has equated its guidelines with long-term (equilibrium) fitness loss, and concluded that existing guidelines for integrated programs affecting primary populations are consistent with a 15% long-term fitness loss, and found that the corresponding level of fitness loss would be achieved by an *effective* pHOS of 2% in an isolated program affecting a primary population (HSRG 2014, Table 3-2)[10]. Because the intent of the HSRG's use effective of pHOS is to more closely reflect gene flow, their 2% pHOS equates approximately to 2% gene flow in EWS Sim. Although we did not run EWS Sim to equilibrium, this level of correspondence with Ford's work and that of the HSRG indicates that EWS Sim do not conflict with previous modeled results of fitness loss caused by gene flow from isolated hatchery programs.

Translating a fitness loss (e.g., relative reproductive success) determined empirically or theoretically to population demographics is not straightforward. The most conservative approach would assume that a fitness reduction of x% would mean that the population would be now be capable of producing on average x% fewer progeny. The alternative would be to apply the fitness loss to a Beverton-Holt, Ricker, or some other production function involving compensatory mechanisms, in which case the loss to population abundance would be less than x%. A good example of this approach is the HSRG AHA model, in which fitness loss is applied to both the capacity and the productivity parameters of a Beverton-Holt function (RIST 2009). Alternatively, in very small populations, a depensatory effect might occur, in which case the abundance loss would be greater than x%.

Our approach in evaluating programs with respect to EWS Sim results is to consider the fitness loss, a direct measure of population productivity decrease, assuming other factors remain constant. This last consideration is very important because the productivity of a population is likely heavily influenced by freshwater and ocean habitat conditions. How much of the total population productivity is genetically determined is unknown but it is likely to be highly variable. Thus, highly productive populations may be able to incur considerable fitness losses and still remain highly productive, whereas low-productivity populations may be highly impacted by further reductions, making population status a key consideration in determination of acceptable fitness loss.

[10] The HSRG modelling differed from ours in that in using effective rather than census pHOS, they explicitly incorporated a specified RRS value for EWS (0.11), whereas in our EWS Sim runs RRS was a function of selection strength and difference between optima. RRS from the EWS Sim runs we deemed biologically plausible averaged 0.17.

Steelhead may have more potential for genetic change through selection relative to other Pacific salmon species that have been studied (Araki et al. 2008). Given the uncertainty regarding the magnitude of fitness loss expected, this possible higher susceptibility to selection argues for a conservative approach to determining acceptable fitness loss in the species in general due to gene flow from hatchery programs. Populations comprising the Puget Sound steelhead DPS vary in viability status, but few could be considered highly productive, which also argues for a generally conservative approach to acceptable fitness loss in these populations. Although general viability criteria have been developed for the DPS, requiring that a specified proportion of populations in each major population group within the DPS reach viable status, no detailed plans have as yet been developed designating which populations must reach viable status. This also argues for a conservative approach to acceptable fitness loss. A final consideration is the conservation value of the programs under consideration. EWS programs may facilitate steelhead harvest while offering some measure of protection to the natural-origin populations. However, they offer no net benefit to the status of these populations, posing genetic risk with no offsetting demographic benefit.

Currently there are no formal benchmarks for acceptable fitness loss due to gene flow from hatchery programs. However, the HSRG gene flow guidelines (HSRG 2009; HSRG 2014) can be considered benchmarks by virtue of their widespread dissemination and implementation. As previously mentioned, the HSRG (2014) recently modeled the long-term fitness loss expected from application of these guidelines, and the fitness loss expected for the highest-level guidelines was approximately 15%. Given all the specific considerations just mentioned, 15% long-term fitness loss seems insufficiently conservative for the proposed EWS programs. At this time, considering the state of scientific knowledge (including uncertainties inherent in the modeling above) and currently undetermined recovery importance of the individual affected populations, the acceptable modeled 25-generation fitness loss for these populations should generally not exceed 10%. We feel this is sufficiently conservative because the model likely over predicts true fitness loss, fitness change each generation is likely very small, and if future research determines that this value should be lower, the impact of an insufficiently conservative level will have been unsubstantial. It is doubtful that fitness loss will be measurable directly, at least in the short term, so management will have to be based on gene flow estimation. The modeled 10% fitness loss level corresponds to gene flow of approximately 2%.

2.2. Estimation of Gene Flow

Gene flow is a seemingly simple concept, but developing straightforward ways to measure it is not simple. For one thing, gene flow from hatchery fish into natural-origin populations is referred to in many NMFS documents and elsewhere as interbreeding or hybridization. This is an oversimplification. In reality, gene flow occurs by two processes: hatchery-origin fish spawning with natural-origin fish and hatchery-origin fish spawning with each other. How well the hatchery-origin fish spawn and how well their progeny survive, determines the rate at which genes from the hatchery population are incorporated into the natural-origin population. The importance of including the progeny of HxH matings as a potential "vector" for gene flow is illustrated by the observation that these fish may have a considerably longer and later spawning season than hatchery-origin fish (Seamons et al. 2012). An appropriate metric for gene flow needs to measure the contributions of both types of matings to the natural-origin population being analyzed. Another consideration is temporal scale. Although there may have been effects from gene flow from earlier, more intensive and widespread hatchery activities, for purposes of analyzing the proposed programs what must be measured is the current rate of gene flow, which is best represented as the proportion of the current naturally produced progeny gene pool:

$Gene\ flow = (2f(HH) + f(NH))/2$, where *f(HH)* is the proportion of naturally produced progeny produced from HxH matings, and *f(NH)* the proportion of progeny produced by HxN[11] matings

WDFW has developed two metrics for measuring gene flow in this way. The first is based on actual genetic data, and is called proportionate effective hatchery contribution (*PEHC*) (Warheit 2014a), hereafter called the "Warheit method." WDFW also has developed an alternative demographic method, hereafter called the "Scott-Gill method," for calculating the expected gene flow that is based on demographic and life history data rather than genetic data (Scott and Gill 2008).

Below we discuss in detail these two methods for estimating gene flow and results from applying them to data on Puget Sound steelhead. It is important to understand in reading this material that the Warheit and Scott-Gill methods estimate the current rate of gene flow (from recent past practices) and expected rate of gene flow (from future practices and proposed HGMPs), respectively, not cumulative gene flow. In other words, the effects analysis is aimed at how much gene flow is occurring or will occur, not how much may have occurred in the past, nor what the cumulative genetic contribution of EWS to the natural-origin steelhead populations has been. Our analysis assumes that natural-origin fish in either analysis may have

[11] As in earlier usage in this document, this is meant to represent both matings between natural-origin females and hatchery-origin males, and vice versa.

some level of hatchery ancestry. In the case of the Scott-Gill method, the natural-origin fish considered in the equation may include the progeny of HxH or HxN matings.

2.3. Estimation of Gene Flow using Genetic Data

2.3.1. Introduction to Warheit Method

Estimation of *PEHC* in Puget Sound steelhead is difficult because, in terms of genetic markers that can currently be analyzed, the differences between the hatchery-origin fish and natural-origin fish are slight, because of common ancestry and possibly gene flow in the past. WDFW has struggled with this problem for several years, and Dr. Ken Warheit, director of the Molecular Genetics Laboratory at WDFW, has developed a method for estimating *PEHC* in situations like this. The method is new, still undergoing refinement, and for that reason has received limited peer review[12]. Because of this, the method has been extensively reviewed by NMFS staff, and refined in response to that review.

The Warheit method involves, in part, comparing genotypes of natural-origin and hatchery-origin fish using the *Structure* program (Pritchard et al. 2000; Pritchard et al. 2010). *Structure* is one of the most widely used programs for inferring population structure, and has also been used for detecting hybrid individuals, frequently between wild and domestic populations. The WDFW Molecular Genetics Laboratory has many years' experience using the program. *Structure* makes use of each individual's multilocus genotype to infer population structure (e.g., hatchery versus wild), given an a priori assumed number of groups or populations. The program will probabilistically assign individuals to populations, or if the admixture option is used, will assign a portion of an individual's genome to populations.

Although *Structure* is the basic analytical engine of the Warheit method, the full method is far more complex than a basic *Structure* analysis. Realizing that assignment portions of an individual's genome to populations must involve error if the genetic distance between the populations involved in the admixture is small, Warheit first investigated this assignment uncertainty in a study of genetic effects of Skagit early winter steelhead[13]. He simulated populations of hatchery-origin and natural-origin fish and their hybrids, then applied *Structure* to determine how well the program classified fish of known ancestry (Warheit 2013). He found that depending on the situation, the proportion of hybrid fish could either be seriously over- or underestimated, and concluded that he lacked sufficient power with 15 microsatellite loci to reliably quantify introgression from early winter steelhead into the wild Skagit River winter steelhead populations, or reliably identify pure unmarked hatchery-origin or hatchery-ancestry fish. Warheit's

[12] Drs. Warheit and Knapp are currently developing a manuscript for submission to a peer-reviewed journal.
[13] We refer to the Skagit report only for presenting the historical development of the method. Any results presented have been superseded by Warheit (2014a).

current (2014a) method applies and extends the lessons learned in the Skagit work. The data set consists of genotypes from up to 192 single-nucleotide polymorphism (SNP) loci. Simulation methods were refined to better model the genetic composition of populations. In addition, Warheit used a likelihood approach to adjust the *Structure*-based assignment proportions, based on the assignment error from analysis of the simulated populations.

NMFS Northwest Fisheries Science Center (NWFSC) staff reviewed a report provided to us in March 2014 that described the method and the results of its application to several Puget Sound steelhead populations (Warheit 2014c). They commented extensively on many aspects of the document (Hard 2014). Because of these comments and additional discussion with SFD staff, the method was refined and the document extensively revised. WDFW provided NMFS with the new draft (Warheit 2014a) in October 2014, which we submitted to NWFSC for review, along with a document by Warheit (Warheit 2014b) detailing his responses to the earlier review. The NWFSC responded with a new review in January 2015 (Ford 2015).

Briefly, the NWFSC reviewers found Warheit's method to be a reasonable, thoughtful, and innovative effort to address genetic introgression from closely related hatchery populations. Importantly, Warheit's approach demonstrated that a naïve application of the *Structure* program would provide misleading results, probably overestimating introgresion. However, they were concerned, as in their previous review, that Warheit's approach may overstate the precision and possibly the accuracy of the estimates. In other words, the confidence intervals may be larger than reported, and point estimates may be biased. They singled out two potential sources of uncertainty. The first was uncertainty associated with sampling, which did not seem to have been taken into account. The second was sensitivity to the many assumptions and choices about model parameters that Warheit used.

These NWFSC comments were expected. The Warheit approach is an innovative complex method that attempts something very difficult, and necessarily involves many assumptions and sources of uncertainty. NMFS staff and Warheit discussed the method and revisions to it extensively during the EIS development process. Confidence intervals were developed, in fact, at the urging of NMFS staff, with the full understanding that they were potentially underestimates. NMFS considers that although sensitivity analysis is necessary, which may spur further refinement of the technique, the Warheit method is not only a reasonable approach to measuring gene flow in this situation, but the best method available.

In response to the comments from NWFSC and others, Warheit and his collaborator Dr. Shannon Knapp (University of Arizona) revised his method (Knapp and Warheit 2016), and WDFW (WDFW 2015a) provided new *PEHC* estimates and confidence intervals based on the revision. The revised methodology has not yet been reviewed by NWFSC.

2.3.2. Application of Warheit Method

WDFW has applied the Warheit method to the Nooksack, Stillaguamish, Snohomish/Skykomish, and Snoqualmie steelhead populations, as well as several other Puget Sound steelhead populations, but has not yet applied it to the Dungeness population because of a lack of genetic data. Table B-2 reports *PEHC* information provided by WDFW (2015a) on these steelhead populations based on recent past practices, along with sampling details[14]. It also reports projected *PEHC* values (Hoffmann 2014), which take into consideration recent program changes that would not have been reflected in the other *PEHC* estimate.

Table B-2. *PEHC* estimates and confidence intervals (CI) based on recent past practices (e.g., last 5-10 years), and projected *PEHC* estimates from proposed early winter steelhead hatchery programs, and sampling details for the Nooksack, Stillaguamish, Skykomish, and Snoqualmie steelhead populations (WDFW 2015a). No *PEHC* estimate is available for the Dungeness Basin. The Stillaguamish sample was not 100% winter steelhead (see text). All values presented as percentages.

Basin	Listed Population	Sample Size and Details	Recent Past Practices *PEHC* and 90% CI	Projected *PEHC* (%) under Proposed HGMPs
Nooksack	Nooksack (W)	246 (2009-2013 adults and juveniles)	1(0-4)	1
	SF Nooksack (S)	66 (2010-2011 adults)	0(0-7)	0
Stillaguamish	Stillaguamish (W)	86 (2006 smolt trap samples)	0 (0-7)	0
	Deer Cr. (S)	157 (1995+2013 juveniles, few 2012-2013 adults)	0 (0-3)	0
	Canyon Cr. (S)	96 (2013 juveniles)	0 (0-5)	0
Skykomish/ Snohomish	Skykomish (W)	21 (2013 adult)	0 (0-20)	0
	Pilchuck (W)	49 (2012 adult)	2 (0-16)	0
	N.F. Skykomish (S)	145 (2004, 2012, and 2013 juveniles and adults)	1 (1-3)	1
Snoqualmie	Snoqualmie (W)	166 (2010-2013 juveniles and adults)	4 (0-12)	1
	Tolt (S)	74 (2010-2012 juveniles)	1 (0-3)	0

[14] The HGMPs also presented this information, but information was updated during the consultation.

The projected values rely a great deal on the *PEHC* estimate, which is subject to imprecision, but are important in that they reflect the proportionate change expected.

Before beginning general discussion of results in Table B-2, some discussion of the Stillaguamish winter steelhead sample is warranted. Warheit (2014a) noted that the Stillaguamish was the most poorly represented system in his analysis. The sample marked in the table as Stillaguamish (W) was a sample of outmigrating smolts at a lower basin smolt trap that undoubtedly collects fish from multiple populations. Assuming that the collection could easily be predominantly winter steelhead smolts, upon NMFS request Dr. Warheit used *Structure* to determine the run-time composition of the sample. Of the fish in the sample that were assignable, 86%-94% were assigned to winter steelhead (Warheit 2016a). Based on the new information from Dr. Warheit, , we decided to include data from this sample for estimating *PEHC* in Stillaguamish winter steelhead, even though WDFW did not proffer it as such. WDFW has not provided an updated confidence interval for *PEHC* based on this sample, but because the updated intervals that have been provided tend to be somewhat larger than those originally provided in Warheit (2014a), we assume an updated confidence interval would be wider than that reported in Table B-2. WDFW also did not provide a projected *PEHC* value, but based on their method, the projected value would have been 0%. However, this sample also yielded a *PEHC* estimate for influence from early summer steelhead[15] (ESS) programs of 18% (Table B-7; Warheit 2014c), which seems to conflict with the classification results described above. Given the fact that the sample is a smolt-trap sample and is a decade old, the *PEHC* estimate for EWS effects should be viewed cautiously.

For the most part, the *PEHC* estimates based on recent past practices are 0%, although confidence intervals go up to 16% in the Pilchuck winter steelhead population and 20% in the Skykomish winter population (Table B-2). Both of these estimates were based on very small samples, and this is likely the major cause of the large confidence interval, but the large confidence is still a concern. Clearly, a new larger genetic sample is needed from the Skykomish. In the case of the Pilchuck population however, *PEHC* is projected to be 0% in the future, because no releases have occurred there since 2009, and none are planned under the proposed programs (WDFW 2016). The largest point estimate, 4% in the Snoqualmie, also has a high upper confidence limit (12%), and is based on a large sample size, indicating a higher level of gene flow than in the other populations affected by the proposed hatchery programs.

[15] Early summer steelhead (ESS) are hatchery-origin steelhead of Skamania stock origin. With the exception of the Dungeness River basin where information is less clear, summer-run and winter-run forms of natural-origin steelhead exist in the other river basins (Myers et al. 2015). Although the return timing of the summer-run and winter-run steelhead differs, there is less difference in the time of spawning (although there is typically some spatial separation). Natural-origin summer-run steelhead may be affected by EWS programs, and natural-origin winter-run can be affected by ESS programs.

However, this *PEHC* estimate was a result of the previous program (recent past practices); the proposed programs differ in several respects from previous operations, including discontinuation of off-station releases and reduction in release from Tokul Creek Hatchery. The projected *PEHC* under the proposed programs is 0%.

Overall then, assuming the *PEHC* estimates are not biased low, and considering the confidence intervals, recent gene flow from EWS programs has been on the order of a few percent, averaging perhaps less than the 2% WDFW standard for populations of high conservation concern, and the expectation is that it will not increase, and significantly decrease in the one population in which the current point estimate exceeds 2%. So these results are encouraging. Gene flow seems to have generally been low, and it is expected to be lower. It must be kept in mind that these results are based on a new method about which there is still considerable uncertainty.

In addition to the uncertainty about the Warheit method already expressed in the NWFSC review (Hard 2014) we have concerns about sample composition. As can be seen in Table B-2, Warheit's analysis largely used pooled samples from multiple years, and multiple life stages. Given the difficulties inherent in sampling steelhead, pooling seems reasonable, but it may have implications for *PEHC* estimates. We discuss this concern in detail in the section below.

2.3.3. Genetic Monitoring

A key part of the proposed HGMPs is a genetic monitoring plan described in Anderson et al. (2014), which is intended to verify that *PEHC* is being maintained at or below stipulated levels. The plan includes sampling in several Puget Sound basins. Table B-3 presents sampling details for the Nooksack, Stillaguamish, Dungeness, Skykomish/Snohomish, and Snoqualmie Basins.

This level of sampling is impressive, especially coupled with sampling efforts elsewhere in Puget Sound. But the plan lacks important details. The plan commits to sampling a maximum specified number of either smolts or adults on a regular basis, but the numbers are the same in all basins, so it appears that there is no link between sample size and analytical power. In the Dungeness River, for example, is a sample of 100 smolts large enough to generate a *PEHC* estimate of the desired precision and accuracy? It is also unclear, given that the specified sample sizes are maxima, how many samples can be expected to be actually collected in a season at the various locations. This would be true even if the traps collected fish from single populations, but most traps can be expected to collect fish from more than one population.

Based on the sample pooling evident in the Warheit report (Warheit 2014a), it seems likely that, because of either analytical demands or sampling difficulties, samples will be pooled. The implications of this procedure are unclear. If *PEHC* is constant over time, then unweighted pooling seems reasonable in principle. However, *PEHC* will undoubtedly vary to some degree, possibly necessitating weighting of samples. In addition, sample sizes may vary widely from year to year. Perhaps samples should be

Table B-3. Genetic sampling plans for Nooksack, Stillaguamish, Dungeness, Skykomish/Snohomish, and Snoqualmie steelhead (Anderson et al. 2014).

Basin	Sample Site	Life stage	N	Population(s) Sampled
Nooksack	Mainstem Nooksack R.	Smolts	≤ 100 annually	Nooksack (W) and (S)
	SF Nooksack R.	Adults	≤ 50 every third year	SF Nooksack (S)
Stillaguamish	Mainstem Stillaguamish R.	Smolts	≤ 100 annually	Stillaguamish (W), Canyon Cr. (S), Deer Cr. (S)
	Deer Cr.	Adults	≤ 50 every third year	Deer Cr. (S)
Dungeness	Mainstem Dungeness R.	Smolts	≤ 100 annually	Dungeness (S/W)
Skykomish / Snohomish	Mainstem Skykomish R.	Smolts	< 100 annually	Skykomish (W) and N.F. Skykomish (S)
	Pilchuck River	Adults	≤ 50 every third year	Pilchuck (W)
Snoqualmie	Mainstem Snoqualmie R.	Smolts	< 100 annually	Snoqualmie (W) and Tolt (S)
	Snoqualmie R.	Adults	≤ 50 annually	Snoqualmie (W)

weighted based on size. Finally, it makes sense that in a given population, a *PEHC* estimate based on adults could differ from one based on smolts, simply because the progeny of hatchery-origin are expected to be less fit than the progeny of natural-origin fish and thus some of them may die before they can be sampled as adults. What then are the implications of pooling adult and juvenile samples?

We also note that there is no directed sampling of the Canyon Creek natural-origin summer steelhead population. Summer steelhead are at low levels in the Stillaguamish basin, with no available escapement estimates, but intrinsic potential estimates of capacity for Deer Creek may be ten times higher than that for Canyon Creek. Canyon Creek fish can be expected to be sampled at low rates at the smolt trap, but at this point sampling this population effectively seems very difficult. In the monitoring plan WDFW has chosen to sample the Deer Creek population intensively to represent Stillaguamish summer steelhead. This not really a deficiency, but the monitoring plan should deal with this issue in more detail.

2.4. Estimation of Gene Flow Using Demographic Methods

2.4.1. The Scott-Gill Method

The Scott-Gill method for estimating gene flow using demographic and life history data is based on the schematic diagram presented in Figure B-1. The method assumes random mating within mating region, and uses estimates of the proportion of spawners that are of hatchery origin (pHOS[16]), the proportion of hatchery-origin and natural-origin spawners in Region B, and the relative reproductive success (RRS) of the HxH and HxN mating types to compute the proportion of the offspring gene pool produced by hatchery-origin fish. Dr. Craig Busack (NMFS) developed the equation in 2006 when he worked at WDFW. Although the value produced by the equation seems to us to be analytically identical to *PEHC,* we will call it *DGF* (demographic gene flow) to prevent confusion as to which metric we are discussing, and to distinguish the metric from the concept.

Hoffmann (2014) presents *DGF* estimates for several Puget Sound winter steelhead populations, including the Nooksack, Stillaguamish, Skykomish, and Snoqualmie populations, along with details on estimation of parameters. Considerable effort went into population-specific development of the overlap parameters, especially in modeling the timing of natural-origin spawners. In Washington, steelhead spawning surveys are ordinarily not done before March 15. Hoffmann (2014) used the temporally truncated information to model pre-March 15 spawning. Because spawning distributions are not known with precision for either the early winter hatchery-origin or natural-origin steelhead populations in most cases, basin specific information on overlap was bracketed with information from the Tokul Creek hatchery population, the best studied winter steelhead hatchery population, and the natural-origin winter steelhead populations in Snow Creek and Clearwater River. Hoffmann used literature values for the RRS of early winter hatchery steelhead, including a range for HxH matings. The parameter most susceptible to error is pHOS, which was estimated from spawning ground surveys and from hatchery-origin fish returning to the hatchery. The total number of fish returning to the hatchery was assumed to be 70-80% of the escapement. This assumption of 20-30% of the hatchery-origin escapement remaining in the river to spawn was considered to be conservative in comparison to earlier estimates by the HSRG of 10-20%

[16] Symbolized by q in the equation in WDFW documents.

(Hoffmann 2014). The Dungeness population was also analyzed but the Scott-Gill method in the HGMP (WDFW 2014a), but using slightly differing assumptions about proportion of hatchery-origin escapement remaining in the river and RRS.

During the review, an algebraic error was discovered in the Scott-Gill equation (Busack 2014), so all previously published *DGF* values were slightly inaccurate. Table B-4 presents updated *DGF* values for steelhead populations in the Nooksack, Stillaguamish, Dungeness, Skykomish, Snoqualmie, and Pilchuck Basins computed with the same assumed values about RRS (0.13 for HxH matings and 0.54 for HxN), and pHOS as proportion of hatchery-origin escapement (30%) (Hoffmann 2015a; Hoffmann 2015b). No Scott-Gill analysis was possible for the summer steelhead populations potentially affected by proposed programs, because these populations are not monitored (WDFW 2014b), and thus no abundance or timing data exist. For information on effects on natural-origin steelhead from summer steelhead hatchery programs, see Section 2.6.

Table B-4. *DGF* values generated from the Scott-Gill equation for the Nooksack, Stillaguamish, Dungeness, Skykomish/Snohomish, and Snoqualmie winter steelhead populations (Hoffmann 2015a; Hoffmann 2015b). All values are expressed as percentages. For recent past pHOS and *DGF*, means are reported with maxima in parentheses. Projected pHOS values were calculated based on 2010-2015 spawning escapement and smolt-to-adult hatchery rack returns assuming 20% and 30% "stray" rates. Projected *DGF* values presented as ranges based on combinations of the two assumed stray rates and of the two assumed RRS values for hatchery-origin fish, and as the mean of those four scenarios. Recent past pHOS and *DGF* values assume the 30% stray rate and higher of the assumed RRS values.

Metric/Data	Population				
	Nooksack	**Stillaguamish**	**Dungeness**	**Skykomish/ Snohomish**	**Snoqualmie**
Escapement years	2010-2015	2002-15, except 2007	2010-2015, except 2012	2003-2014, except 2007 - 2009	2002-2015
O_N	6.21	1.25	4.33	1.96	2.1
O_H	8.38	18.41	16.88	27.9	16.88
Recent past pHOS	3.1 (8.4)	4.8 (17.5)	1.8 (4.2)	8.7 (24.2)	30.0 (56.0)
Recent past *DGF*	0.37 (1.46)	0.61 (3.07)	0.27 (0.82)	1.21 (4.62)	3.98 (14.91)
Projected pHOS	3.0-5.0	3.0-5.1	1.8-3.0	9.0-14.6	8.4-13.5
Projected *DGF*	0.46 (0.19-.84)	0.54 (0.27-0.92)	0.36 (0.18-0.59)	1.58 (0.79-2.73)	1.28 (0.55-2.34)

The *DGF* results are in contrast to the *PEHC* results in that they separate the five programs into two groups. The Nooksack, Stillaguamish, and Dungeness all have a mean projected *DGF* of approximately 0.5%, whereas the two Snohomish programs have mean values 2.5-3 times higher. Because there is not a large difference in overlap values, this distinction seems to be driven by higher pHOS values. Based on mean *DGF*, expected gene flow from all five programs are under 2% gene flow limit; under worst case scenario assumptions (mainly the 30% stray rate assumption) the Snohomish programs may exceed the 2% level. The 30% stray rate assumption was a "worst case" level included in the HGMPs. It is unclear how seriously to consider a worst case so far from the assumed HSRG "stray" rate range of 10%-20% quoted by Hoffmann (2014). However, given that the Scott-Gill model assumes that the returnees return only to the stream where they were released, although it is likely some return to neighboring streams, consideration of values somewhat above 20% is certainly reasonable, but 30% may be unrealistically high.

Comparison of projected DGF values with the recent past values can be misleading. The recent past values are the mean and maximum reflecting what actually happened, using worst case assumptions (30% stray rate and higher RRS values) and including releases that were under the designed program size. The projected values assume the programs will operate at full size, and the means are based on the four combinations of RRS and stray rate values. So the fact that the recent past means are in most cases close to, but slightly lower than, the projected values is to be expected. Possibly a better comparison is the recent past maxima with projected maxima; in all cases, the projected values are considerably lower.

The transparency of the Scott-Gill approach offers a look at the mechanics of the gene flow process that makes these estimates more understandable. For example, in the five-year period 2007-2012, the post-harvest survival rate for returning hatchery fish in the Stillaguamish River was 0.16% (averaging 216 adults from an average release of 131,840 smolts) (WDFW 2014a). Of the estimated 216 fish returning, 151 would return to the hatchery and 65 fish (30% of the return) would remain on the spawning grounds. The natural-origin spawning escapement averaged 1,217 fish, so average pHOS was 5%. Because of temporal segregation only 1.25% of the natural-origin fish and 18.4% of the hatchery-origin fish coincided temporally (15 natural-origin and 12 hatchery-origin fish). The other 1,202 natural-origin fish would spawn among themselves, as would the other 53 hatchery-origin fish. Assuming random mating, this would be expected to result in 94.5% NxN matings, 1% HxN matings, and 4.5% HxH matings. Only 11 natural-origin fish (0.9%) would be expected to mate with hatchery-origin fish. Assuming no differences in success of these matings, the initial proportion of the progeny gene pool originating from hatchery-origin fish would be 5.0%. However, because of the expected low RRS of the hatchery-origin fish (e.g., Araki et al. 2008), this percentage would be reduced to 1.1% (assuming RRS of 0.54 for HxN matings and 0.18 for HxH).

2.4.2. Sensitivity Analysis

This example also illustrates well the chain of logic in using modeled parameter values to generate the *DGF* values. Whatever error exists in the *DGF* is predominantly due to parameter uncertainty, rather than error associated with assumed statistical distributions, so no confidence intervals are included with the estimates in Table B-4. Hoffmann (2014) used a sensitivity analysis to evaluate the effects of parameter uncertainty on the Scott-Gill results. This was a general rather than a basin- or population-specific analysis. Average parameter values for overlap, pHOS, and RRS[17] over all the Puget Sound steelhead populations were analyzed in the document to arrive at an average *DGF*. Each parameter average was

[17] Hoffmann used two values for the RRS of HxH matings (0.02 and 0.13), so used an average of 0.07 in the sensitivity analysis.

then varied individually up and down 50% (Table B-5) to determine the effect on that average *DGF* estimate (Figure B-2). Based on this analysis, results seem most sensitive to pHOS, but are reasonably sensitive to RRS and overlap values. Although this sensitivity analysis is informative, additional sensitivity analysis needs to be done to improve the level of certainty of the *DGF* estimates. First, although basing the analysis on average values makes sense in several ways, it should be done on a population specific basis as well, as the situation for a particular population may deviate considerably from average. Second, multiple parameters should be varied simultaneously. We realize that varying combinations of parameters presents a huge number of options, but this can be limited by focusing on those subject to greatest uncertainty or variability. Third, variation should be done on a biologically realistic basis rather than using an arbitrary scale such as 150% and 50%, because some variables are more subject to variability/uncertainty than others. Biological reality may require the dissection of the input parameters into components and investigating their individual variability/uncertainty. An excellent example is pHOS, which is obviously a function of the estimated number of hatchery-origin and natural-origin fish on the spawning grounds. The former is assumed to be a constant proportion of the escapement, calculated from the known number returning to the hatchery, and the latter is based on redd counts and assumptions about the proportion of the run that spawns before redd surveys begin, itself an input parameter to the Scott-Gill equation. Given this, it is unclear that sensitivity analysis based on varying pHOS up and down 50% adequately captures all the uncertainty/variability in pHOS. Possibly the major source of imprecision and bias is in the redd counts, which are well known to be potentially subject to error. Another obvious candidate for closer scrutiny for biological reality is overlap.

The Seamons et al. (2012) study of performance of EWS at Forks Creek, a small tributary of the Willapa River on the Washington coast, is frequently cited in discussions of risk from naturally spawning EWS, particularly the failure of assumptions about spawning overlap and resulting high proportion of HxN progeny. Given the high visibility for this work, and the obvious potential for applying the conclusions to Puget Sound EWS programs, we consider it important to discuss in detail the potential applications of this research to Puget Sound EWS programs. NMFS requested that WDFW provide supplementary information dealing with this issue (Tynan 2015), and the following discussion is based on WDFW's response (WDFW 2015b), which should be consulted for additional detail. In evaluating the Forks Creek study, there are two primary issues: spawning overlap of natural-origin and hatchery-origin fish, and the presence of HxN hybrids resulting from that overlap. In the Seamons et al. (2012) study, the median day of arrival for hatchery-origin adults was early to middle January, and the median day of arrival for natural-origin (unmarked) adults assigned by Seamons et al. (2012) to the wild category was middle to late April. There was no overlap between the hatchery and wild distribution quartiles, and very little overlap between the 95% CIs (Seamons et al. 2012, Fig. 5). Thus, the spawning overlap in Forks Creek does not appear to be different from the values used in the Scott-Gill modelling (Hoffmann 2015a; Hoffmann 2015b). Because there is no evidence for more spawning, the question is - why does the Forks Creek research indicate a considerably larger number of hatchery-wild hybrids than are detected by Warheit in several basins? The most likely explanations are higher pHOS and higher spawner overlap than would be expected in Puget Sound. Unpublished work in WDFW (2015) indicates that pHOS in Forks Creek is 15%, far higher than in most of the streams in the Proposed Action (Table B-5), so more hybrids would be expected than in lower pHOS systems. The spawner overlap argument is based on size of the system and hatchery location. Hatchery fish were therefore likely to be attracted back to Forks Creek, increasing the spatial overlap of spawning. Thus, the degree of hybridization seen in Forks Creek may be more similar to small river systems with similar characteristics, systems which are quite different in size and hatchery location from the three dealt with in the Proposed Action. A final possibility is an upward bias in assignment of fish to the hybrid category.

This discussion of the Seamons et al. (2012) is in no way intended to weaken the argument for empirical verification of key biological parameters used in the Scott-Gill modelling. In fact, by emphasizing the importance of considering program-specific factors, it strengthens the argument.

Table B-5. Input parameter values used in sensitivity analysis of Scott-Gill method applied to Puget Sound steelhead populations (from Table 11 in Hoffmann (2014)).

Input parameter	Average value over watersheds and cases	Parameter value at a 50% increase	Parameter value at a 50% decrease
$O_{(N)}$	3.63%	5.44%	1.81%
$O_{(H)}$	12.19%	18.29%	6.10%
K1	0.07	0.11	0.04
K2	0.54	0.81	0.27
On Station pHOS	5.05%	7.58%	2.53%

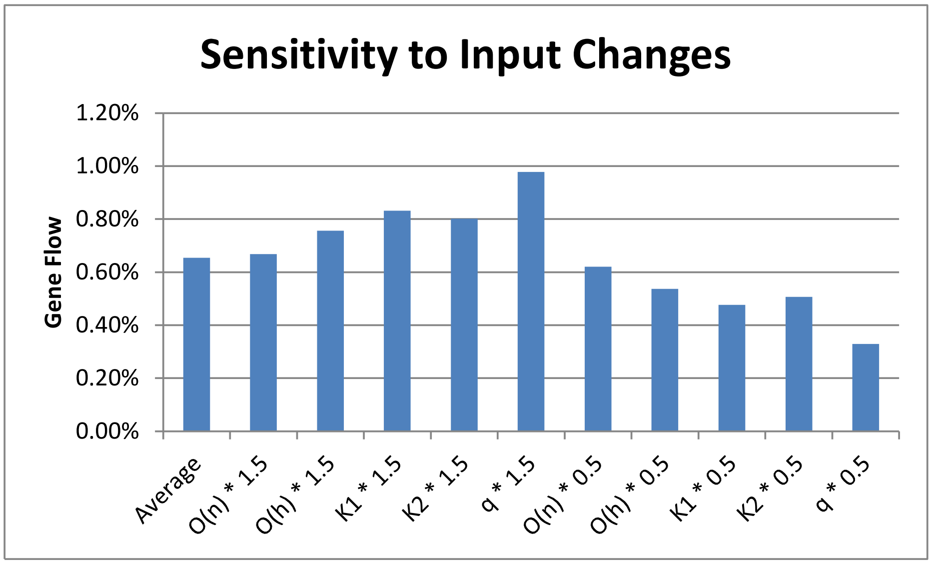


Figure B-4. Gene flow values when varying each Scott-Gill parameter in isolation by a 50% increase and a 50% decrease over the input value averaged over all watersheds and all cases (from Figure 11 in Hoffmann 2014).

2.5. Summary of Results from Both Methods

Table B-6 presents *PEHC* values from recent past practices (e.g., past 5-10 years) and as projected from the proposed programs, and *DGF* values together for easy comparison. In earlier sections we have discussed at some length the need for additional development of the Warheit method (which is ongoing) and associated sampling plans, and the need for a considerably more thorough sensitivity analysis, along with validation through monitoring, of the input parameters used in the Scott-Gill method. The space devoted to detailing those issues should not overshadow the fact that for these five proposed programs, two credible and independent approaches indicate that gene flow, measured either as projected *PEHC* or projected *DGF* should be under 2% in populations affected by the Nooksack, Stillaguamish, and Dungeness programs and likely under 2% in populations affected by the two Snohomish programs. And although we have concerns about the precision of the genetically based results, and concerns about both precision

Table B-6. Summary of analyses of gene flow from early winter hatchery steelhead into listed Nooksack, Stillaguamish, Dungeness, Skykomish/Snohomish, and Snoqualmie steelhead populations. (Data from Table B-2 and Table B-4). DGF values are means, with maxima in parentheses. All values are expressed as percentages.

		PEHC (%)		*DGF (%)*	
Basin	**Listed Population**	**Past Practices (90% CI)**	**Projected**	**Past Practices**	**Projected**
Nooksack	Nooksack (W)	1 (0-4)	1	0.37 (1.46)	0.46 (0.84)
	SF Nooksack (S)	0 (0-7)	0		
Stillaguamish	Stillaguamish (W)	0 (0-7)	0	0.61 (3.07)	0.54 (0.92)
	Deer Cr. (S)	0 (0-3)	0		
	Canyon Cr. (S)	0 (0-5)	0		
Dungeness	Dungeness (S/W)	-	NA	0.27 (0.82)	0.36 (0.59)
Snohomish/ Skykomish	Pilchuck (W)	2 (0 - 16)	0	1.21 (4.62)	1.58 (2.73)
	Skykomish (W)	0 (0 - 20)	0		
	N.F. Skykomish (S)	1 (1 - 3)	1		
Snoqualmie	Snoqualmie (W)	4 (0 - 12)	1	3.98 (14.91)	1.28 (2.34)
	Tolt (S)	1 (0 - 3)	0		

and bias of the demographically based results, we conclude that there would have to have been unreasonably large errors in methods or parameter estimation to have achieved these results if the gene flow was actually larger than the *PEHC* and *DGF* estimates. On the basis of this determination, NMFS concludes that the proposed programs as revised do not pose significant risk through gene flow to Puget Sound steelhead, subject to future validation of gene flow values through monitoring and refinement of gene flow estimation methodology.

2.6. Early Summer Steelhead Hatchery Programs

Steelhead populations in the Nooksack, Stillaguamish, Skykomish/Snohomish, and Snoqualmie Basins are also potentially subject to gene flow from early summer steelhead (ESS) hatchery programs, and *PEHC* estimates are available for these impacts. Table B-7 presents *PEHC* estimates from both summer and winter programs for listed steelhead populations in these basins. The Nooksack populations were included just for the sake of completeness; no summer steelhead are released in the Nooksack Basin, so no gene flow is expected. There is an ESS program in the Stillaguamish, and in that basin the estimates are 0% for both summer steelhead populations, but 18% for the winter steelhead population. However the estimate is based on Table B-7 because it is based on the same sample of smolts discussed in Section 2.3.2. Because of the age of the sample and its mixed composition, we have little confidence that it reflects current gene flow from ESS hatchery fish. However, whatever the past gene flow levels have been, current gene flow levels are likely to be considerably reduced due to the complete cessation of tributary-level outplants of steelhead throughout Puget Sound.

The remaining *PEHC* estimates all pertain to the populations in the Snohomish Basin, which can be influenced by the in-basin Wallace/Reiter ESS program. During the ESA consultation, a decision was made to downsize the program (Unsworth 2016). This and the previously mentioned discontinuation of all tributary-level outplants, are expected to substantially reduce this program's impacts on the Snohomish steelhead populations, and this is reflected in the projected *PEHC* values in the table. The most dramatic reduction is in the Tolt summer steelhead population, where WDFW expects *PEHC* to be reduced from 68% to 0%. It should be noted, however, that for both Snohomish Basin summer steelhead populations with high *PEHC* estimates, Tolt and North Fork Skykomish, the reported values may not truly reflect gene flow, but rather the fact that these two populations have been influenced by past summer steelhead releases, to the point where (Warheit 2014a) considers them "feral" natural-origin populations of ESS. Although accurate estimates of gene flow may be impossible at this time, and perhaps for some time into the future, the program reduction and other programming changes should substantially decrease gene flow over what it has been in the past.

For those populations in Table B-7 with reasonable estimated and projected *PEHC,* gene flow from ESS programs appears to be about the same or less than that from the proposed EWS programs.

Table B-7. *PEHC* estimates based on recent past practices and projected *PEHC* estimates for EWS and ESS hatchery programs in the Nooksack, Stillaguamish, Skykomish/Snohomish, and Snoqualmie steelhead populations (Unsworth 2016; Warheit 2014a; WDFW 2015a).

Basin	**Listed Population**	**EWS**		**ESS**	
		Recent Past Practices *PEHC* and 90% CI	**Projected *PEHC***	**Recent Past Practices *PEHC* and 90% CI**	**Projected *PEHC***
Nooksack	Nooksack (W)	1(0-4)	1	0 (0-2)	NA
	SF Nooksack (S)	0(0-7)	0	0 (0-7)	NA
Stillaguamish	Stillaguamish (W)	0 (0-7)	0	18 (13-25)	NA
	Deer Cr. (S)	0 (0-3)	0	0 (0-5)	NA
	Canyon Cr. (S)	0 (0-5)	0	0 (0-5)	NA
Skykomish/ Snohomish	Skykomish (W)	0 (0-20)	0	5 (0-31)	2
	Pilchuck (W)	2 (0-16)	0	2 (0-14)	0
	N.F. Skykomish (S)	1 (1-3)	1	95 (88-99)	NA
Snoqualmie	Snoqualmie (W)	4 (0-12)	1	3 (1-10)	0
	Tolt (S)	1 (0-3)	0	68 (55-79)	0

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WDFW. 2014c. Snohomish/Skykomish River Winter Steelhead Hatchery Program HGMP. Steelhead (*Oncorhynchus mykiss*) Early Winter Stock. November 25, 2014. 69p.

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Appendix C

Socioeconomics Methods

Prepared by TCW Economics

October 2015

This Socioeconomics Methods appendix describes the methods and data used to describe baseline conditions in Subsection 3.5, Socioeconomics, and to conduct the analysis of effects on the socioeconomic resource as described in Subsection 4.5, Socioeconomics, of the Puget Sound early winter steelhead (EWS) draft environmental impact statement (DEIS). The analysis of socioeconomic impacts is based on baseline catch conditions associated with five EWS programs that use eight hatchery facilities located in five Puget Sound river basins (Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins) (Subsection 3.5, Socioeconomics). Note the Skykomish River and Snoqualmie River are major tributaries in the Snohomish River basin. The socioeconomic effects of changes in hatchery operations and in affected recreational fisheries are estimated for each alternative analyzed in the DEIS. Effects of changes in production under the alternatives on tribal commercial and ceremonial and subsistence also are considered qualitatively in Subsection 3.5, Socioeconomics, and Subsection 4.5, Socioeconomics, of the DEIS.

Impact Assessment Methods

Estimates of regional economic impacts derived from assessing hatchery production costs and expected fishing effort associated with EWS caught in recreational fisheries are expressed primarily in terms of personal income accruing to households within local areas (county or multi-county regions). Local personal income is considered a key indicator of economic activity, and is used in economic analysis to evaluate distributional effects on local and regional economies associated with hatchery production. Estimates of local personal income, which the Pacific Fishery Management Council also derives to annually assess the economic effects for its salmon allocation decisions, reflect the wages, profits, and property income associated with expenditures made by sport anglers (and commercial fishers) in their fishing pursuits. For this analysis, the only effects on fisheries that are quantified are those occurring in freshwater recreational fisheries, which are understood to represent the most substantial fisheries affected by the EWS hatchery programs.

In addition to the personal income generated by angler participation in recreational fisheries affected by EWS hatchery production, EWS hatchery facilities operating in the Puget Sound region also affect local and regional economies by providing employment opportunities for those working at the eight hatchery facilities where EWS are produced, and through the procurement of materials and services needed for operation of the hatchery facilities.

The following four analytical steps were followed to conduct the analysis of socioeconomic effects of the five EWS programs that are the subject of this assessment.

Step 1: Compile Hatchery Production and Catch Data for the EWS Hatchery Programs

Hatchery production information for the five EWS hatchery programs was used to generate statistics on the relative contribution of each of the five programs to the total EWS production and estimated adult returns throughout the Puget Sound region. This production information is included in Table C-1. Sport catch data (in numbers of fish caught) for EWS reported by the Washington Department of Fish and Wildlife (WDFW) in its annual Sport Catch Report were compiled (Table C-2) and used to estimate a recent 10-year average catch by river basin.

Table C-1. Summary of EWS releases by river basin, under the DEIS alternatives.

River Basin (County)	Hatchery Facilities	Smolt Release by Alternative			
		1 No Action	2 Proposed Action	3 50 percent Reduction	4 Native Broodstock
Dungeness (Clallam)	Dungeness River Hatchery Hurd Creek Hatchery	0	10,000	5,000	10,000
NF Nooksack (Whatcom)	Kendall Creek Hatchery McKinnon Pond	0	150,000	75,000	150,000
NF Stillaguamish (Snohomish)	Whitehorse Ponds	0	130,000	65,000	130,000
Skykomish (Snohomish)	Wallace Hatchery Reiter Ponds	0	256,000	128,000	256,000
Snoqualmie (King)	Tokul Creek Hatchery	0	74,000	37,000	74,000
Total	8	0	620,000	315,000	620,000

Step 2: Convert Estimates of Baseline Catch to Sport Angler Trips

The catch data compiled in Step 1 required conversion to angler trips so that the hatchery production of adult steelhead would match the regional economic impact (REI) factors (REI per angler trip) used to estimate total personal income. As mentioned above, quantitative estimates of economic values were only derived for sport fisheries because the most substantial effect of the EWS hatchery program are understood to be on recreational fisheries. (The relatively limited effect on tribal commercial fisheries was addressed qualitatively in the impact assessment, primarily due to tribal catch data limitations.) For recreational fisheries, estimated catch was converted to angler trips, considering the influence of catch-and-release fishing as part of angler effort. Then, the REI factors were applied to the estimates of angler effort to calculate personal income effects of total angler effort associated with affected fisheries. (Note that these estimates of REI include the effect on angler effort from both wild and hatchery fish.).

The primary sources of information used for deriving the catch per unit of effort (CPUE) factors for steelhead fishing in the freshwaters of Puget Sound included: 1) state-wide estimates of steelhead sport fishing effort (2,706,340 freshwater steelhead trips, as derived from angler days reported by the U.S. Department of the Interior, Fish and Wildlife, U.S. Department of Census Bureau, 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (personal communication from James Dixon to TCW Economics, September 21, 2015) and 2) estimates of total sport catch of steelhead in statewide freshwaters (152,285 fish, as reported in the WDFW's Catch Record Report for the 2011-12 winter season.

The resulting conversion factor of 17.77 trips per steelhead caught, which is generally consistent with findings by Scott and Gill (2008), was then applied to the 10-year average of winter-run steelhead sport catch (4,412 fish caught; Table C-2) in the affected EWS rivers in the Puget Sound region to estimate the baseline number of sport angler trips (78,400 trips).

Table C-2. Sport harvest estimates of early winter steelhead by Puget Sound river basin.

	Harvest Year (winter of)										
River Basin[1]	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	10-year Average
Dungeness	24	32	38	21	7	19	26	57	93	100	42
Nooksack	447	238	216	69	49	56	106	59	83	104	143
Stillaguamish	733	625	852	521	116	108	105	282	430	266	404
Skykomish	3600	2045	2595	2453	1019	1114	1563	2439	2106	1604	2226[2]
Snoqualmie	3257	1443	1476	1206	800	900	877	1806	1643	985	1597[2]
										Total	4412

Sources: WDFW final Sport Catch Reports for 2004-05 through 2011-12 (http://wdfw.wa.gov/fishing/harvest/); Preliminary estimates for 2012-13 and 2013-14 from WDFW data (J. Dixon, Pers. Comm. with Eric Kraig, WDFW).

[1] River-basin level harvest estimates include estimated harvest in both the mainstem and tributaries of each river.

[2] Average totals for the Skykomish and Snoqualmie River basins include the reported catch from the lower mainstem Snohomish River (10-year average of 330), proportionally divided and added to each of the Skykomish and Snoqualmie 10-year averages (52 percent to 48 percent, respectively), based on the baseline hatchery program release sizes in each of the river basins.

Step 3: Estimate Regional Economic Impacts (Total Personal Income) of EWS Hatchery Production under Baseline Conditions

Estimates of regional economic impacts, as measured in terms of total personal income, were developed based on consideration of both hatchery operations, and of the effect on recreational fisheries that are supported by the five EWS hatchery programs. For estimating REI of hatchery operations, estimates of annual operating costs and employment for the eight hatchery facilities involved in producing EWS were compiled from information in the HGMPs (WDFW 2014a, WDFW 2014b, WDFW 2014c, WDFW 2014d, WDFW 2014e). (It should be noted that these hatcheries produce species other than EWS so the estimates of annual operating costs [$2.02 million] and employment [19.34 full-time equivalent positions] reflect total hatchery operations, not just for EWS. It was assumed that the EWS programs account for an estimated average of 28 percent of the total annual operating costs of the eight hatchery facilities, or about $561,300, based on the total production at EWS hatchery facilities that is comprised of steelhead (in pounds) (DEIS Table 4).

The estimates of operating costs and jobs were then converted to estimates of total personal income based on factors derived from State of Washington hatchery budget information used in a study for Trout Unlimited of the economic contribution of salmonids to the Southeast Alaska economy (TCW Economics 2011). According to this study, wages and other forms of personal income accounted for 57 percent of total operating costs, and procurement of materials and services required for production accounted for 43 percent of total operating costs. Based on these factors, direct income (i.e., wages and other forms of compensation) generated by the eight hatchery facilities that produce EWS is estimated at $1,114,975. (Note that the percentages used for this analysis were adjusted to 55 percent for wages and other compensation, and 45 percent for procurement.) Of this total, it is estimated that $312,190 (28%) is related to EWS production.

Based on a feasibility study of hatchery improvements at the Leavenworth Hatchery Complex in eastern Washington (McMillan 2015), secondary income effects (i.e., wages generated by the spending of hatchery workers' income and from procurement of materials and services) accounted for 59 percent of the direct income effects, which represents $657,835 ($1,114,975 * 0.59) of direct income associated with production of all species at the eight hatchery facilities. Total income generated by production at the eight hatchery facilities where EWS are produced is therefore estimated at $1,772,810 ($1,114,975 + $657,835). Based on an estimated 28 percent share of hatchery operation costs associated with EWS production, the regional economic effect, as measured in personal income, associated with production of EWS-only would be about $496,400 ($1,772,810 * 0.28).

For analyzing the regional economic effects of the recreational fisheries supported by EWS production at the eight hatchery facilities, an REI factor of $67.30 per trip for steelhead fishing in freshwaters of Puget Sound was applied to the estimated number of angler trips (78,400 trips) under baseline conditions to estimate regional economic impacts (direct and secondary personal income) of the EWS hatchery programs. This REI factor ($67.30 per trip) reflects the estimated regional economic impact per angler trip, as expressed in 2015 dollars and derived for a preliminary socioeconomic study (The Research Group 2009) prepared for the DEIS on the Columbia River Basin Hatchery Operations and Funding of Mitchell Act Hatchery Programs. The REI factor, originally developed in 2007 dollars, was adjusted to 2015 dollars using the state-wide consumer price index for all goods and services. Applying this REI factor to the estimate of baseline number of trips (78,400 trips) resulted in an estimate of about $5.28 million in regional income effects.

Under baseline conditions, total regional income effects from both hatchery operations (including production of all species at EWS hatchery facilities) and from affected EWS recreational fisheries in Puget Sound are estimated at $7.05 million annually. When hatchery production costs of EWS-only are considered, the total personal income effects are estimated at $5.77 million annually.

Step 4: Analyze Effects of Changes in Hatchery Production under the Alternatives on Recreational Fishing Effort and Regional Economic Conditions

For the alternatives analysis in Subsection 4.5, Socioeconomics, the baseline conditions described above were used to characterize the expected regional economic effects and associated effects on fisheries under Alternative 2 (Proposed Action) (Subsection 4.5.2, Proposed Action). The effects of implementing Alternative 1 (No Action) would be to eliminate the marginal economic benefits of the contribution of EWS hatchery production to angler trips and associated regional economic effects described under Alternative 2 (Proposed Action). The baseline conditions described in Subsection 3.5, Socioeconomics, and explained above also would reflect the socioeconomic effects of implementing Alternative 4 (Native Broodstock) because there would be no change in hatchery production under Alternative 4. Note that there could be some additional production costs associated with the transitioning to native broodstock but the potential socioeconomic effect of this would be expected to be minimal.

For analyzing the socioeconomic effects of Alternative 3 (50 percent reduction), the number of steelhead angler trips compared to baseline conditions would be expected to decline. A number of factors were considered to assess the magnitude of this reduction in angler effort, including the relative contribution of EWS hatchery fish to the overall number of catchable adult steelhead fish; angler perceptions of how a potential reduction in the abundance of adult steelhead populations would affect fishing quality; and how the steelhead fisheries on the affected rivers are managed.

Although these and other issues related to potential effects on angler effort from changes in (hatchery) fish abundance are very specific to the affected EWS rivers, the relevant literature does suggest some key conclusions concerning how angler effort could generally be expected to respond to a 50 percent reduction in the number of adults from EWS hatchery programs in the affected Puget Sound rivers.

Based on a review of relevant literature (e.g., Allen and Ahrens 2012; Andrews and Wilen 1988; Hooton 1985; Johnson and Carpenter 1994; Johnson and Adams 1988; Johnson and Adams 1989; Johnston, et al. 2006; Larson and Lew 2013; and Murdock, J. 2001), a key conclusion that can reasonably be drawn is that the relationship between the number of trips taken and the abundance of adult catchable fish is 'inelastic', a term indicating that, in most situations of changes (increases or declines) in the abundance of adult catchable steelhead over time, the percentage change in the number of angler trips would be expected to change by less than that of abundance. In other words, as abundance goes down, the number of angler trips also would be expected to decline but at a more reduced rate of change. Because of the many site-specific factors that affect this behavioral response, primary research, such as conducting surveys of steelhead anglers on the affected rivers, is the only potentially statistically-valid method to estimate this response.

Conducting angler surveys to estimate angler response to an expected 50 percent reduction in the releases of fish from EWS hatchery programs is beyond the scope of this assessment; however, based on a review of the relevant literature and on expert judgment, a reasonable estimate is that angler effort could be expected to decrease at a rate that is about 50 percent of the rate of change in numbers of EWS hatchery fish. Assuming this response, the estimated number of angler trips could be expected to decline by about 19,600 trips (78,400*0.5*0.5). Based on a REI factor of $67.30 per trip, this would result in a personal income reduction of an estimated $1.32 million annually, or 25 percent of the contribution under the baseline condition.

In addition to the regional economic effects related to affected recreational fisheries, a 50 percent reduction in the production from EWS hatchery programs also would affect personal income supported by hatchery operations. Consistent with information described by NMFS (2014), a 50 percent reduction in hatchery production of EWS would not be expected to affect the number of FTE positions at the eight hatchery facilities because these facilities also produce other fish for other hatchery programs (e.g., salmon). However, there would be a reduction in the procurement of materials and services needed. This reduction in procurement would be expected to correspond with the reduction in production of EWS fish, which would translate to an estimated $65,100 in reduced procurement for materials and services related to EWS hatchery programs, relative to baseline conditions.

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Appendix D

Public Comment Analysis Summary

March 2016

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1.0 Introduction

This appendix provides a summary of public comments and responses to those comments received on the draft Environmental Impact Statement (EIS) (80 Fed. Reg. 70206, November 13, 2015). It presents the methodology used by NMFS in reviewing and sorting the comments, and presents a synthesis of all comments that address common themes.

2.0 Summary of Public Comment Process

1. **November 13, 2015** – A Notice of Availability of the *Draft 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* was published in the Federal Register (80 Fed. Reg. 70206, November 13, 2015), marking the formal beginning of the public review period for the document.
2. **November 4, 2015** (on or before this date) – NMFS notified interested tribal organizations, agencies, and the public of the availability of the draft EIS via email and a press release. Compact disc copies of the draft EIS were mailed to agencies and public libraries.
3. **November 4, 2015** – The draft EIS and all of the appendices were made available for review and download online at the National Marine Fisheries Service (NMFS) West Coast Region (WCR) website at http://www.westcoast.fisheries.noaa.gov/hatcheries/pshatcheries/ps_ews_deis.html
4. **December 28, 2015** – The 45-day public review period ended.
5. **January 5, 2016** – Compiled comments on the draft EIS were made available on the project's website at http://www.westcoast.fisheries.noaa.gov/hatcheries/pshatcheries/ps_ews_deis.html

3.0 Summary of Submissions

During the public review period, NMFS received a total of 2,086 submissions (email or letter, including form-emails and form-letters) on the draft EIS from the following:

Agencies

U.S. EPA

U.S. Department of Interior

Washington Department of Fish and Wildlife

Tribes and Tribal Organizations

Jamestown S'Klallam Tribe

Lummi Nation

Tulalip Tribes

Northwest Indian Fisheries Commission

Organizations

Wild Fish Conservancy

The Conservation Angler

Trout Unlimited/Wild Steelhead Initiative

Wild Salmon Center

Hatchery Scientific Review Group

Puget Sound Anglers

Coastal Conservation Association

Steelhead Trout Club of Washington

Ilwaco Charter Association/Westport Charterboat Association

Individuals

103 non-form submissions

Form-emails – Puget Sound Anglers (1,193 submissions)

Form-emails – Coastal Conservation Association (632 submissions)

Form-emails or form-letters – Other (142 submissions)

These comments were used to inform development of the final EIS.

4.0 Response to Public Comments

The National Environmental Policy Act (NEPA) requires government agencies to include in the final EIS all the substantive comments received on the draft EIS. The final document must include responses to the comments or comment summaries, indication of changes to the draft EIS because of those comments, and an indication of where such changes were made in the document. This appendix provides a synthesis of all public comments that address common themes. Individual comment submissions and responses are available from NMFS and posted on the project's website at http://www.westcoast.fisheries.noaa.gov/hatcheries/pshatcheries/ps_ews_deis.html.

4.1 Analysis of Public Comments

Each comment submission on the draft EIS was read to insure that all substantive comments were identified. The term 'substantive comment' generally refers to an assertion, suggested alternatives or actions, data, background information, or clarifications relating to the EIS or its preparation. Comments were related to one or more of the eight issue categories listed below.

Issue Category	Description
Alternatives	Alternatives analyzed, preferred alternative
Analysis	Analysis of effects on resources, methods
Comment noted	Comment acknowledged
Cumulative Effects	Analysis of cumulative effects
Data	New data, sources
Editorial	Corrections and clarifying edits
Monitoring	Adaptive management, monitoring, evaluation, research
NEPA	NEPA requirements; NEPA process; relationships to the Endangered Species Act (ESA)

Substantive comments were identified and responses were developed for each substantive comment and recorded for the project administrative file. Individual comments and responses were also posted to the project's website identified above. In reviewing comments received on the draft EIS, NMFS found that there were common themes in many of the comments. NMFS has organized the common themes into a series of "global comments." Rather than responding to these comments individually and likely repeating very similar, if not exact, responses, NMFS has generated a series of global responses to address these commonly themed, global comments. These global responses cover four areas of general comment:

1. Comments addressing alternatives analyzed
    a. Comments stating a preference and/or ideas for the EIS Preferred Alternative

   b. Comments seeking more information on native broodstock programs (Alternative 4 – Native Broodstock)

2. Comments addressing the NEPA and EIS process

   a. Comments asking that the EIS process be expedited
   b. Comments asking for additional analyses
   c. Comments asking that comments on previous NEPA documents be incorporated by reference

3. Comments addressing the range of alternatives analyzed

   a. Comments suggesting that an alternative be analyzed that reviews increases in production levels and is more supportive of harvest than the existing alternatives

4. Comments addressing analyses in the EIS

   a. Comments on genetic analyses
   b. Comments on extent of overlap/interactions between early winter steelhead and natural-origin steelhead
   c. Comments on lack of a steelhead recovery plan
   d. Comments on the role of habitat for steelhead

Below are the global responses to each of these comment themes.

4.2 Global Responses to Public Comments

1. Comments Addressing Alternatives Analyzed

a. Comments stating a preference and/or ideas for the EIS Preferred Alternative

NMFS did not identify a preferred alternative in the draft EIS. During the public review of the draft EIS, NMFS encouraged reviewers to consider the effects (presented in Chapter 4 and Chapter 5), and comment on how NMFS should formulate a preferred alternative for publication in the final EIS and record of decision (ROD).

Many comments identified their preferred alternative. These preferences covered a wide range of ideas, including comments stating a preference for one or more of the alternatives analyzed in the draft EIS, comments on an alternative that increased hatchery production, and comments calling for alternatives outside the scope of this EIS, such as a new fisheries management scheme for Puget Sound steelhead. The Preferred Alternative is identified and discussed in Subsection 2.2.5, Alternative 5 (Preferred Alternative).

b. Comments seeking more information on native broodstock programs (Alternative 4 – Native Broodstock)

Some comments requested more clarity on the characteristics of native broodstock programs (Alternative 4). This response provides additional detail on the nature of that program type. Clarifying text was also added to the appropriate subsections of the EIS.

In contrast to the early winter steelhead hatchery programs analyzed in the EIS in which the hatchery-origin steelhead would be "isolated," meaning they are intended to be different from the natural-origin steelhead, native broodstock programs (under Alternative 4) would be considered "integrated" programs, which are hatchery programs whereby the natural environment drives the adaptation and fitness of a composite population of fish that spawns both in a hatchery and in the natural environment. In these programs, 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).

Information on integrated hatchery programs for steelhead is also found in the Puget Sound Hatcheries Draft EIS (e.g., see Subsection 2.2.2.1, Artificial Production Strategies, Subsection 3.2.7.4.6, Benefits – Viability, and Appendix B, Hatchery Effects and Evaluation Methods for Fish) (NMFS 2014a).

Fish from native broodstock programs are intended to spawn in nature and may provide conservation as well as harvest benefits. The fish used for broodstock and produced by the hatchery programs would be included as part of the listed Puget Sound Steelhead DPS. Best management practices would be applied to ensure that the hatchery-origin fish did not become more than moderately diverged genetically from the natural-origin source stock.

There are a number of integrated steelhead programs using native broodstock in Washington, Oregon, and Idaho. The following steelhead native broodstock programs currently operate in Puget Sound:

- Hood Canal Steelhead Supplementation Project, a recovery program for the Dewatto River, Duckabush River, and South Fork Skokomish winter steelhead
- Green River Wild Winter Steelhead Program, a recovery program for native winter steelhead in the watershed
- White River Winter Steelhead Supplementation, a conservation program to rebuild the native White River winter steelhead

- Lower Elwha Hatchery Native Steelhead, a program implemented initially to preserve and restore the native Elwha steelhead population, but planned for transition when the population is recovered to include Lower Elwha tribal fisheries harvest as a primary objective

Native broodstock programs for steelhead may have both positive and negative effects for several resources, as described in Chapter 4, Environmental Consequences, and as briefly summarized below.

Genetic Considerations

Returning hatchery-origin steelhead adults that are not harvested and stray into natural-origin steelhead spawning areas would pose lower risks to diversity and fitness to natural-origin steelhead from interbreeding. This is because the hatchery-origin and natural-origin components of the combined population would largely be interchangeable – similar genetically, and sharing similar behavioral traits, such as adult return and spawn timing. However, in spite of applying best management practices, unavoidable changes may in time lead to some level of genetic divergence (e.g., through inadvertent hatchery-influenced selection, or domestication). In addition, if the hatchery-origin component of the return is much larger than the natural-origin component, then within-population diversity of the natural-origin population may be reduced over time as the hatchery-origin fish spawn naturally.

Potential "Mining" of Natural-origin Steelhead Populations

In a native broodstock program, status of the donor natural-origin population is a primary concern because natural-origin spawners are removed (e.g., "mined") to create and sustain the programs. Removals from natural-origin population would be carefully managed and limited to avoid detrimental impacts on the naturally spawning component. In most instances, the production levels from the hatchery programs would have to start out and remain small, until the abundance of the donor natural-origin steelhead populations becomes large enough to sustain removal of larger numbers of fish for broodstock. Native broodstock programs would typically begin with conservation as the primary objective. The programs may transition to also include harvest objectives, after the abundance of the total (hatchery-origin and natural-origin) steelhead population increases to a level where the naturally spawning component is healthy enough to support harvest. The time needed for this transition would depend on a wide range of circumstances affecting the abundance of natural-origin steelhead populations (including the condition of freshwater and marine habitats).

Fishery Considerations

Under the ESA 4(d) Rule for listed salmon and steelhead, hatchery-origin fish that are part of a listed ESU or DPS are marked or tagged so that they can be differentiated from natural-origin fish that are subject to ESA section 9 take prohibitions. This "take" exception exists to allow harvest of listed hatchery-origin steelhead and salmon that are surplus to hatchery broodstock and natural spawning needs. The types of fisheries that might target hatchery-origin steelhead from native broodstock programs, while minimizing incidental impacts to natural-origin steelhead, include mark-selective catch-and-release recreational fisheries. Tribal net fisheries might use non-selective gear types (e.g., beach seines, traps, tangle nets) for which live release of incidentally caught natural-origin steelhead is feasible. For example, NMFS has authorized fisheries in the Columbia River basin directed at externally marked hatchery-origin steelhead from integrated hatchery programs, while maintaining sufficiently low exploitation rates on natural-origin steelhead (e.g., Wells Summer Steelhead program, and fisheries directed at returns of hatchery-origin steelhead in the upper Columbia River). The four examples of Puget Sound native broodstock programs mentioned above are in their conservation phases.

There are a number of other fishery considerations. These include use of an allowable harvest rate for the comingled natural-origin steelhead in the same fishing areas, and the amount of unintentional fishing-related mortality on listed steelhead. Limitations on harvest rates may lead to escapements of hatchery-origin steelhead into natural-origin steelhead spawning areas – a desirable result in the early stages of native broodstock programs, when conservation objectives predominate. Fisheries on hatchery-origin steelhead from the programs would likely occur in March through June, coinciding with the time when natural-origin steelhead return. In some watersheds, and in some years, flow conditions during these spring months may hamper opportunities for successful fisheries, especially for recreational fishers.

Regulatory/Administrative Processes

As described in Subsection 2.2.4, Alternative 4 (Native Broodstock), NMFS's ESA section 4(d) regulations do not provide NMFS with the authority to order changes of this magnitude as a condition of approval of the HGMPs. NMFS must make a determination that the HGMPs as proposed either meet or do not meet these regulatory standards.

To initiate native broodstock hatchery programs, the co-managers would need to submit HGMPs for the programs to NMFS for review and approval under the ESA. This would re-initiate several administrative and regulatory processes. NMFS would have to consider inclusion of the programs proposed in the HGMP(s) as part of the listed Puget Sound Steelhead DPS, so that any viability benefits could be considered in ESA listing and status reviews/decisions for the DPS. When completed, the new HGMP(s) would be evaluated by the federal agencies for effects on ESA listed fish under ESA section 4(d) and section 7.

Cost Considerations

Overall, the costs to develop and implement native broodstock programs should be similar to those of the early winter steelhead hatchery programs. This assumes equivalent in-hatchery egg-to-smolt survival rates and rearing costs; similar smolt-to-adult return levels; and hatchery facility operation and staffing requirements and costs. Costs during the initial stages of the program implementation may be greater due to the need to acquire natural-origin steelhead broodstock (e.g., weirs, traps, seining, gillnetting, snagging, or hook-and-line actions). In many if not most cases, economic benefits from fishing would likely be less at the outset due to conservation-oriented harvest constraints, but over time and given similar production levels, these benefits would be similar to those associated with early winter steelhead programs.

2. Comments Addressing NEPA and the EIS Process

a. Comments asking that the EIS process be expedited

Some comments expressed strong interest in the timeliness of the EIS process and asked that it be expedited, because in the view of the commenters, if the process were prolonged it may conclude too late for the juvenile steelhead being reared in the hatchery programs being reviewed to be released into the natural environment and out-migrate to sea. The comments stressed that failure to release the fish would have the fundamental effect of terminating the programs, since adult early winter steelhead would not be returning in future years to continue the programs after completion of the EIS process.

It should be noted that, in contrast, NMFS also received requests to extend the draft EIS public comment period. NMFS did not provide a comment extension because (1) the draft EIS was available to the public prior to the formal commencement of the comment period, (2) the public had the opportunity to comment on analyses of the hatchery programs covered in the draft EIS previously in response to the draft EIS for Puget Sound hatcheries, and the draft Environmental Assessment (EA) for three of the hatchery programs considered in this EIS and (3) NMFS was responsive to public interest in making its NEPA and ESA decisions prior to the time when juvenile steelhead reared under the programs would be biologically ready to migrate into the marine environment (spring). In summary, NMFS prepared the final EIS with careful consideration of all public comments and extension requests while balancing responsiveness to the co-manager's request for an ESA 4(d) Rule exemption.

b. Comments asking for additional analyses

Some comments suggested that the EIS be withdrawn or needed additional analysis. In response, NMFS made text changes in the final EIS (see list in the Summary section of this final EIS).

c. Comments asking that comments submitted on previous documents be incorporated by reference

Some comments requested that comments they had submitted to NMFS on previous NEPA reviews of salmon and steelhead hatchery programs in Puget Sound (e.g., on the 2014 Puget Sound Hatcheries Draft EIS, and/or the 2015 Puget Sound Early Winter Steelhead Draft EA) be considered and incorporated by reference into this final EIS. In addition to the comments submitted on the draft EIS, NMFS considered all comments from those requesting that their previous comments be incorporated by reference using the following approach:

1. NMFS identified all submissions on the draft EIS that requested that their previous comments on the Puget Sound Hatcheries Draft EIS and the Puget Sound Early Winter Steelhead Draft EA be incorporated by reference.

2. NMFS then reviewed this set of comments to identify issues raised specific to the scope of analysis in this draft EIS.

3. NMFS addressed these draft EIS-related issues, and all other new issues received by other commenters, in this final EIS.

3. Comments Addressing the Range of Alternatives Analyzed

a. The EIS should include an alternative that increases production levels and is more supportive of harvest than the existing alternatives

Several comments suggested that an increased production alternative should be included in the analysis. That potential alternative was discussed in Subsection 2.3, Alternatives Considered But Not Analyzed in Detail, and not evaluated in the EIS because it was expected that it would present incrementally higher environmental impacts on various resources than the Proposed Action. Analysis of such an alternative would not help inform NMFS' response to the co-managers' request for an exemption from ESA take prohibitions under the ESA 4(d) Rule, because the ESA and the 4(d) Rule are focused on limiting impacts to ESA-listed species.

As described in the draft EIS (e.g., Subsection 1.3, Purpose of and Need for the Proposed Action), the EIS will not document whether the hatchery programs meet requirements of the ESA. Those decisions will be made through processes and reflected in documents consistent with the ESA and applicable regulations.

4. Comments Addressing the Analysis within the EIS

Comments on the draft EIS's effects analysis centered on four core issues: (a) genetic analyses, (b) extent of overlap/interactions between early winter steelhead and natural-origin steelhead, (c) lack of a steelhead recovery plan, and (d) role of habitat for steelhead.

a. Comments on genetic analyses

Several comments identified concerns related to the analysis of genetic effects in the draft EIS. These concerns covered several aspects of the analysis, including:

- Effects on genetic analyses from assumptions regarding spawner overlap
- The reliability of gene flow results
- Cumulative effects analysis for genetic and demographic effects
- Methods used in genetic analyses

Comments addressing the effect on genetic analyses from assumptions regarding overlap between early winter steelhead spawners and natural-origin spawners

Comments identified several assumptions regarding the low estimates of overlap of hatchery-origin and natural-origin steelhead spawners in time and space that WDFW had proposed for use in evaluating the potential for reproductive interaction and potential effects of gene flow. Comments point to NMFS' acceptance of a WDFW "policy assumption," as opposed to an informed decision, regarding the distribution of hatchery-origin and wild-origin spawn timing (e.g., no wild spawning occurs prior to March 15, and that little if any hatchery spawning occurs after March 15). These and other similar comments argued that the overlap values analyzed in the EIS likely underestimate the potential for gene flow from early winter steelhead to natural-origin steelhead.

The comments may have overlooked the analyses in Appendix B in the draft EIS and as updated in Appendix B, Section 1, Within-population Diversity Effects, and Section 2.4.1, The Scott-Gill Method, of this EIS. The overlap values used in the demographic gene flow (*DGF*) analysis were generated by a careful extrapolation by Hoffmann (2014) of observed steelhead redd counts into the period before March 15. NMFS' examination of Hoffmann's work suggests, at least for the populations analyzed, that natural-origin fish do not spawn in large numbers before March 15. If large numbers of steelhead do spawn before March 15, only a strongly bimodal spawning distribution would be compatible with the distributional data present in Hoffman (2014). Such a bimodal distribution is unlikely (see Global Response 4b).

NMFS considered the comments and affirmed that the approach used in its analysis is reasonable. See Global Response 4b for a description of available information on the spawner overlap of early winter hatchery-origin steelhead with natural-origin steelhead.

Comments addressing the reliability of gene flow results

Some comments questioned the current estimates of hybridization rates and total genetic contribution rates (proportionate effective hatchery contribution, or *PEHC*) of hatchery-origin fish to the natural-origin steelhead populations in selected Puget Sound basins, as analyzed in the draft EIS.

NMFS has considered comments related to the current genetic analysis and its ability to accurately detect levels of hybridization between hatchery-origin and natural-origin steelhead populations and finds that the genetic analyses in the EIS are reasonable. It is important to note that the current method being employed by WDFW in the HGMPs is designed to estimate the current (i.e., not past or cumulative) level of gene flow between hatchery-origin and natural-origin steelhead. The older genetic data referred to in comments (e.g., Phillips et al. 1982; Phelps et al. 1994, 1997) was not collected with this intent. The older studies were undertaken with the intent of genetically characterizing steelhead populations within the state of Washington. Given the known history of steelhead stocking in the state, especially in certain regions, the authors of the studies speculated on the effects on diversity this stocking may have had, but their work was not definitive. These older genetic data from should not be disregarded, but recognized as resulting from far fewer genetic markers and analyzed with less sophisticated technology than techniques used today. Finally, those studies were not intended to address gene flow rates.

The key problem in estimating gene flow between early winter steelhead and natural-origin steelhead is the genetic similarity between the two, both because of possible gene flow in the past but also because of common ancestry. The first serious "modern" attempt at estimating contemporaneous levels of gene flow was developed in recent work done in the Skagit River basin and referenced in the draft EIS and comments (Pflug et al. 2013; Warheit 2013). This work, while applying more advanced means of processing the information from the DNA markers and with use of the computer program *Structure*—which enables assessment of individual fish lineage—showed the large potential for misclassification of individuals in terms of hatchery parentage, as acknowledged in comments.

As explained in Appendix B of the EIS, Dr. Warheit modified his method considerably because of his experience with the Skagit River steelhead work. Comments also focused on perceived differences in results between the earlier Skagit work and the Warheit (2014) work that is referred to in the draft EIS, with respect to Finney Creek, a Skagit tributary. The later work by Warheit (2014), in addition to further development of assignment error correction methods for *Structure*, showed samples from Finney Creek to be more strongly aligned, proportionally, with the summer-run populations in the Skagit River than the winter-run populations. When this alignment was taken into account, the previously high levels of presumptive hybridization between the early winter steelhead and the natural-origin population were resolved to much lower levels.

See Global Response 4b for a discussion of information on the overlap between hatchery-origin and natural-origin steelhead spawners, particularly during the early part of the spawning season.

Comments regarding cumulative effects analysis for genetic and demographic effects

Some comments suggested the analysis should include a cumulative assessment of genetic effects. Additionally, they expressed concern about the "demographic" effects that the cumulative gene flow rates may have on small natural-origin populations. These concerns, as well as further development of NMFS' analytical methods, have resulted in an expanded analysis of genetic effects in Appendix B of the EIS, including a review of potential cumulative effects. These updated methods were used to develop the results summarized in the EIS (Subsection 3.2.3.1, Genetic Risks, and Subsection 4.2, Salmon and Steelhead). Please also see revisions in Section 2.1 of Appendix B.

Comments addressing the methods used in the genetic analysis

<u>Scott-Gill Method</u>

Some comments expressed concerns with assumptions utilized in the evaluation of potential gene flow estimated with the Scott-Gill method (i.e., equation) (Scott and Gill 2008), stating that this method likely underestimates the potential gene flow rate. These assumptions include the use of the March 15 date for the start of wild fish spawning, not including the impact (cumulative) of the progeny of HxN[1]and HxH matings coming back to spawn in the next generation, and the lack of analysis of the role that precocial male hatchery-origin early winter steelhead may play in the gene flow rates.

[1] H = hatchery-origin, and N= natural-origin.

See Global Comment 4b for responses related to the potential overlap of hatchery-origin and natural-origin spawners, particularly in the early spawning timeframe.

The comment is correct that the effects of naturally-produced progeny—from pure HxN or HxH parental matings—and the cumulative effect that they may have when returning to mate as natural-origin adults, is not evaluated through the use of the Scott-Gill method. In response, NMFS has included new modeling of genetic effects, including the potential cumulative effects on fitness, in Section 1 and Subsection 2.1 of Appendix B. This information was used to develop the results summarized in the EIS (Subsection 3.2.3.1, Genetic Risks, and Subsection 4.2, Salmon and Steelhead).

The potential effect that precocial male hatchery-origin early winter steelhead play in interbreeding with natural-origin steelhead is further evaluated in the response to Global Comment 4b.

Warheit Method

Comments pointed to several technical areas of concern related to the use of the Warheit method to empirically estimate rates of recent gene flow between hatchery-origin and natural-origin steelhead populations. The primary areas of concern were: 1) the genetic distance (Fst) set between the hatchery-origin and natural-origin steelhead populations in the simulation element of the Warheit method, 2) the criteria established to classify individual fish as to lineage, and 3) the confidence intervals around the *PEHC* point estimates.

1) Some comments questioned Dr. Warheit's purported use of a pre-hatchery Fst of 0.02 in his modeling. The comments noted geographic regions (e.g., Puget Sound and the California coast) where Fst between natural-origin steelhead populations exceeds 0.02. Intra-region Fst values are expected to vary between different geographic regions because it is a function of distances between populations, population size, and gene flow rates, which can be unique to each region, based on geologic, hydrologic, and, in the case of Puget Sound, recent glaciation processes.

   The actual pre-hatchery Fst value produced from the MS simulation step of Dr. Warheit's method was 0.027, as shown at the bottom of Table S5 (Warheit 2014). This value (Fst=0.027) represents an average of the 10 highest Fst estimates from the MS simulations, which likely best represents the evolutionary relationship between the early winter hatchery-origin steelhead and the natural-origin populations of steelhead in Puget Sound. The parameters used in the MS simulations (e.g., broadly stated – hierarchical relationships, genetic diversity within populations, genetic differentiation, and the number of single nucleotide polymorphisms) can be found in the Methods section of Warheit 2014 (including Table S1).

2) Some comments contend that the decisions Dr. Warheit had to make regarding classification of individual fish as to lineage were policy decisions, and that his decision rules should have been precautionary in nature to avoid “the worst kinds of mistakes.” Any classification scheme involves trade-offs between different types of mistakes. Any individual doing the classification has to consider these and develop a rule set. In Dr. Warheit’s case, his rule set was aimed at objectively classifying fish with the intent of being as accurate as possible (Warheit 2014).

3) Some comments expressed concern that the confidence intervals for *PEHC* are based on the point estimate (as is common in statistics) , rather than the true value of *PEHC*, and feel some sort of Bayesian approach involving the distribution of introgression would have yielded more reliable confidence intervals. The difficulty with what the comments propose is that a distribution of introgression, which is unknown, would have to be assumed (called the prior distribution). The resulting statistics would then be very much dependent on this prior distribution. Given what is truly known about gene flow from early winter steelhead programs, it is doubtful there is a credible way to develop a defensible prior distribution.

Another concern some comments raised was the 0.25 confidence interval criterion for labeling a component of *PEHC* as unreliable. The confidence interval estimation method has been refined since the draft EIS was published, and the analysis no longer uses the 0.25 criterion (Appendix B).

b. Comments on extent of spawner overlap and interactions between early winter steelhead and natural-origin steelhead

A number of comments suggested that information in the draft EIS on interactions between early winter steelhead and natural-origin steelhead (especially regarding extent of interbreeding) is flawed in the context of available field observations and studies. Comments suggested that the draft EIS underestimates spawner overlap resultant hybridization rates. As acknowledged in the draft EIS (e.g., Subsection 3.2.3.4, Masking, and Subsection 3.2.3.5, Incidental Fishing Effects) there are differences of opinion about the extent of spawner overlap. After considering comments on the draft EIS, NMFS feels the information used in the EIS is reasonable, for the reasons described here. See also Global Response 4a for information on genetic aspects of the spawner overlap.

Overview of observational field studies of spawner overlap

<u>Skagit River</u>

McMillan (2015a) reported that spawner overlap was substantial in five tributaries in the Skagit River basin based on field observations of estimated redd counts, and personal assignments of the fish species creating the redds and their origin (hatchery-origin or natural-origin). The conclusions reached by McMillan (2015a) are extrapolated from observations of very limited numbers of fish. For example, only six natural-origin steelhead were observed during the entire 5-year period surveyed, including one unmarked steelhead (potential natural-origin) that was observed prior to March. In addition, a total of five hatchery-origin steelhead were observed during the entire 5-year period surveyed, and none were observed after March 12. Within the 5-year period, no hatchery-origin steelhead were actually observed spawning with natural-origin steelhead.

NMFS considered information in McMillan (2015b) from five watersheds in the mid-Skagit River basin. That information suggested that 17 percent of all steelhead redds had been constructed prior to March 15 in the 2014/15 spawning season, and 50 to 67 percent of these early redds were constructed by hatchery-origin steelhead. This equates to an estimated 8.5 to 5.6 percent of the natural-origin steelhead redds being constructed prior to March 15. However, these results are not likely representative of the entire population. For example, telemetry studies within the Skagit River system (Pflug et al. 2013) indicate that most of the earliest arriving natural-origin steelhead are from the middle Skagit River reach. WDFW spawning ground survey data indicate that the earliest natural-origin spawners are typically observed in middle Skagit River tributaries such as Finney and Grandy Creeks (Brett Barkdull, WDFW, personal communication cited in Pflug et al. [2013]). WDFW spawning ground survey data indicate that estimates of redds per mile surveyed are higher from January through February than the first half of March, further suggesting many of the early redds in McMillan (2015a, 2105b) were likely hatchery-origin steelhead. This interpretation is consistent with the genetic analysis of Warheit (2014) in Finney Creek who found no hybrids in unmarked adult steelhead, and one adult that was the progeny of only hatchery-origin parents. These findings further suggest minimal or no hybridization in Finney Creek.

McMillan (2015a) found that large numbers of coho salmon were observed from January through early March, out-numbering observations of steelhead 28:1. However, the estimated number of redds in McMillan (2015a) from January to mid-March was only 4.7 coho redds per steelhead redd. This over five-fold difference between the ratios of estimated coho salmon to steelhead redds suggests that an error was probably made regarding which species produced which redds. During the years surveyed, the majority (63 percent) of the estimated steelhead redds observed prior to mid-March occurred during a 3-year period when steelhead redds out-numbered coho salmon redds 1.2 to 1, but only coho salmon were observed in the streams. This further suggests McMillan (2015a) erred in the assignment of redds to species.

In further reviewing Skagit River steelhead spawner information, NMFS compared redd count data in McMillan (2015a) to data collected by WDFW (2015) in the same Skagit River tributary locations and during the same time periods. This comparison found substantial differences between survey results. McMillan (2015) reported over three times as many redds observed in three Skagit River tributaries than observed by WDFW's professionally trained and experienced spawner survey crews. WDFW's data indicate that redd count observations of McMillan (2015a) likely overestimated the number of steelhead redds constructed during the years surveyed in common.

In Hoffman (2014), river-specific redd data for the Skagit River and Nookachamps steelhead populations and a statistical gamma function were used, indicating that an estimated 4.96 percent of the redds were constructed prior to March 15.

Other Information from Puget Sound

Data from other sources and locations in Puget Sound also suggest that the degree to which early winter steelhead and natural-origin steelhead spawners overlap in Puget Sound spawning areas is low. For example, recently collected spawning ground survey data from the Nooksack River indicate that approximately 5 percent of the steelhead redds were observed prior to March 15 (WDFW, unpublished spawning ground survey data). In another example, comprehensive spawning ground surveys conducted in 2015 in the Dungeness River basin indicate that approximately 4 percent of observed redds were observed prior to March 15 (Jamestown S'Klallam Tribe, unpublished spawning ground survey data). In 2009, extensive early surveys were conducted in the mainstem Pilchuck River (tributary to the Snohomish River) and only three redds (2.5 percent of total redds observed) were observed prior to April 10 (WDFW, unpublished spawning ground surveys). All three redds were observed on February 12, suggesting these redds were likely constructed by hatchery-origin steelhead. Hoffman (2014) used river-specific redd data and a statistical gamma function to estimate that 6.2, 2.1, 1.96, and 1.25 percent of steelhead redds are constructed prior to March 15 in the Nooksack, Snoqualmie, Skykomish, and Stillaguamish Rivers, respectively.

Forks Creek, Washington Coast

Finally, NMFS also considered Forks Creek (Willapa River tributary) steelhead studies that were emphasized in comments (e.g., Seamons et al. 2012). Comments suggested that over 30 percent of the Forks Creek juveniles appeared to be HxN hybrids. Although there are uncertainties associated with the methods used, the estimate of 30 percent is questionable because it does not appear to consider multiple factors, including:

- There is no estimate of the Willapa River steelhead population's introgression with early winter steelhead; therefore, any population scale effects are conjecture.
- Forks Creek is entirely dissimilar to the watersheds being considered in the EIS; it would be expected that a coastal, lowland, rain-dominated watershed like Forks Creek would, in general, have a much earlier spawn-timing than the watersheds within the project area (snow-melt dominated mid- to late-spring hydrographs).
- Forks Creek is the source of water for the hatchery; thus the highest possible amount of introgression would be expected in the creek as hatchery-origin adults return to their home stream to spawn.
- Forks Creek did not operate as an isolated hatchery program; the program incorporated natural-origin broodstock.
- Forks Creek passed excessive numbers of hatchery-origin steelhead onto the spawning grounds, allowing potential interactions with the earliest natural-origin steelhead.
- Forks Creek studies do not track the amount of introgression within the hatchery, which makes it impossible to estimate the amount of introgression that occurred under natural spawning conditions.
- Forks Creek studies do not consider or discuss the potential effects of multiple generations of off-station releases within the Willapa River basin prior to development of their baseline "wild" population, or how such releases may have resulted in a feral spawning aggregation within the hatchery's water supply stream.

Occurrence of residuals and contribution of precocial males

Comments suggest that the draft EIS failed to consider effects from residuals and precocial males. As described in Subsection 3.2.3.2, Competition and Predation, residuals are hatchery-origin steelhead that out-migrate slowly, if at all, after they are released. Precocial males are defined in the PS Hatcheries Draft EIS (NMFS 2014a) as juvenile hatchery-origin males that exhibit qualities of sexual maturity at an unusually early age.

The draft EIS acknowledges that the spawner "region" shown in Figure 1 in Subsection 3.2.3.1, Genetic Risks, and in Appendix B, assumes that all spawners are returning adults. It also acknowledges that the resident form of steelhead (rainbow trout) and precocious hatchery-origin males may contribute to spawning by adults. However, in a study in an Olympic Peninsula stream, McMillan (2007) found that residual hatchery-origin males accounted for only 0.35 percent of the observed males attempting to mate. Thus, from this study and other available information that is acknowledged in Appendix B, and in the Puget Sound Hatcheries DEIS (NMFS 2014a), NMFS would expect the effect of precocial males to be negligible.

Loss of diversity represented by early returning natural-origin steelhead

Comments suggest that releases of hatchery-origin early winter steelhead (primarily by fisheries targeting early winter hatchery-origin steelhead) hamper what was once a much larger early-timed return of natural-origin early-timed winter steelhead. As described in Subsection 3.2.3.4, Masking (and also see Subsection 3.2.3.5, Incidental Fishing Effects), evidence suggests that historically, there were more early-timed natural-origin steelhead than occur presently, and that diversity is an important aspect of life history diversity. Information on early-timed natural-origin winter run steelhead and associated spawner overlap with early winter hatchery-origin steelhead is described earlier in Global Comment 4b. Subsection 1.7.12, Recovery Plans for Puget Sound Salmon and Steelhead, identifies how recovery criteria (including diversity as a viable salmon population parameter, along with abundance, productivity, and spatial structure) will be applied. See also Global Comment 4c.

c. Comments on lack of steelhead recovery plan

Several comments suggest that the lack of a recovery plan for Puget Sound steelhead hampers analysis of the hatchery programs with regard to the potential contribution to recovery of early returning natural-origin steelhead. Environmental review under NEPA requires use of the best available information. Despite the utility of recovery plans in NEPA analyses, there is no requirement that recovery plans be completed to enable a NEPA "hard look" analysis of effects of the Proposed Action and alternatives to environmental resources. The recovery plan is acknowledged in the draft EIS as a plan related to the action, in Subsection 1.7.12, Recovery Plans for Puget Sound Salmon and Steelhead. NMFS used the best available information, including the most recent 5-year status review and viability information.

d. Comments on the role of habitat for steelhead

Several comments suggested that the draft EIS did not adequately describe the role habitat has played as a factor in the decline, and continues to play in the recovery of, the Puget Sound steelhead DPS, especially when relative to the effects from early winter steelhead hatchery programs. Other comments suggested that habitat for steelhead is in better condition than others have argued, and that the effects from early winter steelhead keep natural-origin steelhead from fully utilizing existing and newly restored habitat. In the context of the Purpose of and Need for the Proposed Action described in Subsection 1.3, the role of habitat is addressed extensively in the draft EIS, for example in Subsection 3.2.1, General Factors that Affect the Presence and Abundance of Salmon and Steelhead, and Chapter 5, Cumulative Effects.

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