NATIONAL MARINE FISHERIES SERVICE

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

Elwha Channel Hatchery Summer/Fall Chinook salmon Fingerling and Yearling, Lower Elwha Fish Hatchery Steelhead, Lower Elwha Fish Hatchery Coho Salmon, Lower Elwha Fish Hatchery Fall Chum Salmon, and Elwha River Odd and Even Year Pink Salmon Programs.

NMFS Consultation Number: NWR-2012-9426

Action Agencies: NOAA's National Marine Fisheries Service (NMFS)
National Park Service
Bureau of Indian Affairs
U.S. Fish & Wildlife Service

Program Operators: Lower Elwha Klallam Tribe (LEKT)
Washington Department of Fish and Wildlife (WDFW)

Affected Species and Determinations:

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

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

Consultation Conducted By: National Marine Fisheries Service, Northwest Region

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

Date: 12/10/12

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Table of Contents

Table of Tables

Table of Figures

1. INTRODUCTION

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

1.1. Background

This biological opinion (opinion) constitutes NMFS' review under section 7 of the ESA of its proposed determination under limit 6 of the ESA 4(d) rules for listed Puget Sound Chinook salmon and listed Puget Sound steelhead. The proposed 4(d) determination may affect Puget Sound Chinook salmon, Puget Sound steelhead, and eulachon, as well as critical habitat designated for Puget Sound Chinook and eulachon. NMFS proposes to make a determination about whether the hatchery programs jointly operated by Washington Department of Fish and Wildlife (WDFW) and the Lower Elwha Klallam Tribe (LEKT) adequately address the criteria established for Limit 6 of the ESA 4(d) Rule. This action is taken in response to receipt of five Hatchery and Genetic Management Plans (HGMPs) submitted by the LEKT and WDFW in accordance with Limit 6, detailing the proposed operation of the hatchery programs (Table 1). Two of the on-going hatchery programs release ESA-listed Chinook salmon and steelhead, and three other programs release non-ESA listed coho, fall chum, and pink salmon into the Elwha River watershed. The biological opinion (opinion) and incidental take statement portions of this document were prepared by the NOAA's National Marine Fisheries Service (NMFS) in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, *et seq*.), and implementing regulations at 50 CFR 402. With respect to designated critical habitat, the following analysis relied only on the statutory provisions of the ESA, and not on the regulatory definition of "destruction or adverse modification" at 50 CFR 402.02.

Table 1. Joint State/Tribal Elwha River watershed Hatchery and Genetic Management Plans and the primary program operators.

Hatchery and Genetics Management Plan	Program Operator
Elwha Channel Hatchery Chinook salmon	WDFW
Lower Elwha Hatchery Native Steelhead	LEKT
Lower Elwha Hatchery Coho Salmon	LEKT
Lower Elwha Hatchery Chum Salmon	LEKT
Elwha River Odd and Even Year Pink Salmon	LEKT and WDFW

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

This opinion and EFH conservation recommendations are both in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act") and underwent pre-dissemination review. The project file for both consultations are on file at the Salmon Management Division (SMD) in Portland, Oregon.

1.2. Consultation History

WDFW and LEKT have operated salmon and steelhead hatchery programs in the lower portion of the Elwha River watershed for decades (Figure 1). Artificial propagation of the Elwha River Chinook salmon population commenced in 1914, with consistent, annual fish releases supported by WDFW's Dungeness Hatchery beginning in 1953. Initial juvenile Chinook salmon releases from WDFW's Elwha Channel Hatchery site began in 1974 (WDFW 2012), and continue through the present. Consistent year-to-year releases of juvenile coho salmon, steelhead, and fall chum salmon from the LEKT's initial hatchery location on the lower Elwha River near the estuary began in 1976 (LEKT 2012a; LEKT 2012b; LEKT 2012c). The tribe constructed a new hatchery (Lower Elwha Fish Hatchery) upstream of the initial site, and fish production and releases were moved entirely to the new location in 2010. On-station hatchery releases of steelhead by the tribe were preceded by truck plants of the species by the Washington Department of Game (now included as part of WDFW) into the lower Elwha River for many years in the 1950s and 1960s (Ward et al. 2008; LEKT 2012a).

The WDFW and LEKT hatchery programs were implemented to preserve genetic resources and to mitigate for impacts on fisheries caused by construction of the Elwha and Glines Canyon dams in 1910 and 1927, respectively. Before the dams, salmon and steelhead abundance ranged between 380,000 and 500,000 natural-origin adults (DOI et al. 1994, DOI 1996). Average annual abundance, comprised of mostly hatchery produced fish, is now about 5,500 fish.

Access to 90% of the spawning and rearing habitat in the Elwha was blocked by the dams (Pess et al. 2008). Appproximately 90 miles of mainstem river and tributary habitat and another 26 miles of floodplain channel habitats in seven low-gradient, alluvial valley bottoms were lost (Pess et al. 2008). The dams also interrupted the natural function of the river ecosystem degrading remaining habitats downstream. Over 24 million cubic yards (19 million cubic meters) of sediment has been captured in the two reservoirs behind the dams over the last 100 years (Duda et al. 2008), adversely affecting not only the lower river system, but also depriving the critical habitat in the estuarine and nearshore environments of necessary sediment material. Truncation of alluvial transport of sediment, between 1939 and 2002, reduced spawning habitat below the dams by more than 75% (Pess et al. 2008). The recruitment of large woody debris from the upper watershed was virtually eliminated by the dams (Pess et al. 2008), and the two reservoirs behind the dams created "heat sinks" during the summer, substantially increasing downstream water temperature to the detriment of the fish. The presence of the two dams has been identified as the single largest factor limiting recovery of Elwha River salmon and steelhead (Ruckleshaus et al. 2005; SSPS 2007; Ward et al. 2008). The decline in Elwha River salmonid abundance resulting from dam placement and operation has severely affected the culture and livelihood of the Lower Elwha Klallam Tribe and the ability to fulfill their treaty-reserved fishing rights (Busch 2008). For these reasons, hatchery programs were implemented by WDFW and the LEKT to partially replace lost natural salmon and steelhead abundances and maintain adult returns of the species to the Elwha River.

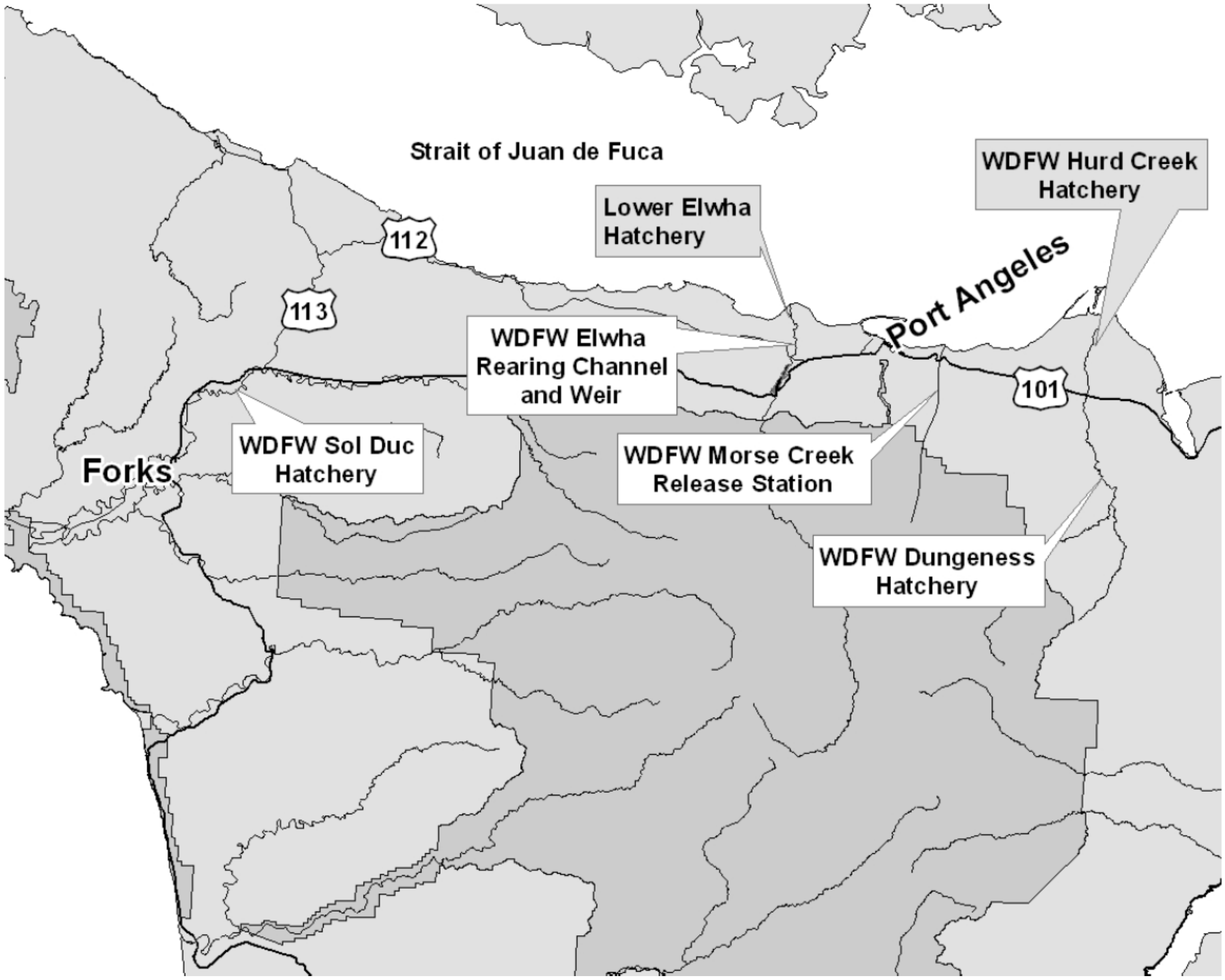

Figure 1. The locations of primary and satellite hatchery facilities used for proposed Elwha River Basin salmon and steelhead supportive breeding programs (from Ward et al. 2008).

In 1992, the U.S. Congress enacted the Elwha River Ecosystem and Fisheries Restoration Act (Act) (Public Law 102-495). The Act funded the federal acquisition of the two dams and required a specific plan to achieve full restoration of the Elwha River ecosystem and fisheries. The U.S. Department of the Interior (DOI et al. 1994) subsequently published the Elwha Report, which found that only through removal of both dams could full restoration of native fish populations be achieved.

Following the decision to remove the dams from the Elwha River, two anadromous salmonid species present in the basin were listed under the ESA: the Puget Sound Chinook salmon Evolutionarily Significant Unit (ESU) (64 FR 14308, March 24, 1999) and the Puget Sound steelhead Distinct Population Segment (DPS) (72 FR 26722, May 11, 2007). In response to the ESA-listing of Chinook salmon, in 2005, WDFW and the Puget Sound tribes ("co-managers") completed two resource management plans (RMP - WDFW and PSIT 2004; PSIT and WDFW 2004) as the overarching frameworks for 114 HGMPs, including HGMPs for the Elwha hatchery programs. The HGMPs described how each hatchery program would operate including effects on listed fish in the Puget Sound region.

In 2004, the co-managers submitted the two RMPs and 114 HGMPs to NMFS for ESA review under limit 6 of the ESA 4(d) rule (50 C.F.R. 223.203). Of the 114 HGMPs, 75 were state-operated including 27 Chinook salmon programs, 22 coho salmon programs, 2 plans for pink salmon, 4 plans for chum salmon, 2 plans for sockeye salmon, and 18 HGMPs for steelhead. The Puget Sound Tribes submitted 38 HGMPs, including 14 Chinook, 13 coho, 9 chum salmon, and 2 steelhead. USFWS submitted 1 HGMP for its coho salmon program at Quilcene National Fish Hatchery.

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

Among the 114 HGMPs were four draft plans developed by WDFW and LEKT describing proposed hatchery programs for Elwha River Chinook salmon, steelhead, coho salmon, and fall chum salmon. Prior to submittal, the four draft Elwha River HGMPs were subjected to extensive review by state, federal, and tribal agencies, independent scientific groups, and the public (Appendix Table 1). The initial Elwha River steelhead HGMP described artificial propagation actions for two winter-run steelhead stocks – a Chambers Creek-lineage population produced for harvest augmentation purposes, and a native Elwha River population produced for preservation and restoration purposes.

Separately from the proposed action reviewed in this opinion, 114 other Puget Sound HGMPs are under review for ESA and NEPA compliance. This will lead to determinations of whether the plans address criteria defined in the ESA (4)d Rule Limit 6 for the Puget Sound Chinook salmon ESU and (where applicable) the Hood Canal summer chum salmon ESU [see 65 FR 42422 (July 10, 2000), and as amended 70 FR 37160 (June 28, 2005)] and in the 4(d) Rule for the Puget Sound Steelhead DPS [73 FR 55451 (September 25, 2008)]. For HGMPs determined through NMFS review to satisfy the 4(d) Rule criteria, ESA section 9 take prohibitions will not apply to hatchery activities managed in accordance with the plans. To meet NEPA requirements associated with NMFS's eventual 4(d) determinations on these 114 programs encompassing the entire Puget Sound region, an Environmental Impact Statement (EIS) is being completed to disclose to the public the likely environmental effects of the proposed hatchery programs, and of alternative hatchery production scenarios under the programs. A Draft EIS will be released for public review and comment in the spring of 2013 and a FEIS and Record of Decision (ROD) to follow.

Take associated with the collection of Chinook salmon adults for use as broodstock for the Elwha Channel Hatchery Chinook salmon program has been previously exempted by NMFS. In 2006 NMFS issued an incidental take statement (ITS) together with an ESA section 7 biological opinion issued to the NPS (NMFS 2006a). NMFS issued these documents at the conclusion of a formal consultation for the "Elwha River Ecosystem and Fisheries Restoration Project". As a term and condition, to be exempt from section 9 take prohibitions, the 2006 ITS provided that the NPS must rescue and remove adult Chinook salmon from the Elwha River and move the fish to the WDFW rearing channel, to the Lower Elwha Klallam Tribe's fish hatchery, or to unaffected river habitat above the dam sites to reduce the level of take from sediment releases. In a reinitiated consultation regarding dam removal effects on listed fish, NMFS completed a second biological opinion on the Elwha River Ecosystem and Fisheries Restoration Project in 2012, which superseded the 2006 opinion (NMFS 2012b). The 2012 opinion incorporated NMFS' earlier findings with updated information to newly address take of listed steelhead, which had been listed as threatened in 2007 after completion of the initial NMFS (2006a) opinion (NMFS 2012a). NMFS also provided a refreshed take statement applicable to Chinook and steelhead, as well as other changes through the updated consultation. NMFS incorporates by reference this 2012 biological opinion (NMFS 2012b). The new opinion analyzed two scenarios - the collection of steelhead adults for supportive breeding and gene conservation purposes and the collection and relocation of fish upstream of the disturbed areas to spawn naturally and ultimately included a term and condition requiring removal of steelhead from the river to minimize listed fish take associated with the effects of dam deconstruction (sediment and turbidity).

Commensurate with the decision to remove the two Elwha dams, and following the ESA listings of Chinook salmon and steelhead, the LEKT, Olympic National Park (ONP) of the NPS, WDFW, the FWS, and the NMFS Northwest Fisheries Science Center (NWFSC) collaboratively developed a scientific framework for preserving and restoring anadromous fish populations in the Elwha River. Known as the Elwha River Fish Restoration Plan (ERFRP - Ward et al. 2008), it identified the general multiagency approach and scientific framework for preserving and restoring the remaining anadromous salmonid populations for the ten-year period before, during, and after the process of dam removal using supportive breeding. The primary objective of the ERFRP was to set out a vision for reestablishing self-sustaining anadromous salmonid populations and habitats. The ERFRP recommended various plans and schedules for hatchery programs to be implemented by the four HGMPs, and also identified processes for monitoring and evaluating the effects and performance of the hatchery-based preservation and restoration efforts in meeting ERFRP objectives. The ERFRP was subjected to extensive review and comment throughout its formation (Appendix Table 2) and was modified based on comments received prior to its finalization as a NMFS NWFSC technical memorandum (Ward et al. 2008). The ERFRP is a working document that is subject to revision as appropriate and while it is not binding on NMFS' decision here it is informative on various hatchery issues. NMFS has carefully considered the information provided in the ERFRP and has made adjustments based on that information, but as a technical memorandum the ERFRP does not dictate the outcome of this consultation.

The authors of the ERFRP recognized that restoration of anadromous fish populations could occur in the Elwha River in the absence of hatchery-based supportive breeding, although the time frame and fish population sources for natural recovery would be highly uncertain (Ward et al. 2008). There is no precedent for this situation, the removal of two large dams on top of five critically depressed populations of anadromous salmonids, two of which are at risk of extinction and federally protected, and thus it was prudent to opt for a restoration strategy that preserved as many options as possible. The lowest risk option, and the one recommended by the ERFRP, was to combine supportive breeding and passing adult fish upstream of the disturbed area to spawn naturally. The desire to ensure that useful progress towards fish restoration occurred within a 20- to 30-year time frame was also a factor.

Identifying and developing the preferred role for the use of hatcheries in the recovery process resulted from extensive consultation within the region. Discussions focused on finding a balance between the goals of ecosystem restoration, preserving stocks of fish unique to the Elwha River, producing fish capable of successfully integrating into the natural environment, and reducing the length of time necessary to preserve the remaining native stocks and achieve restoration of self-sustaining salmon and steelhead populations (Ward et al. 2008).

In 2012, WDFW and the LEKT submitted revised versions of the Elwha Chinook, coho, fall chum, and pink salmon and steelhead HGMPs for 4(d) determination (WDFW 2012; LEKT 2012a; 2012b; 2012c). The HGMPs were modified from previous drafts submitted to NMFS in 2005 and again in December, 2011, and after review by the Hatchery Scientific Review Group in January 2012 (HSRG 2012). The LEKT and WDFW requested a review of the plans by the HSRG prior to their submittal to NMFS to help ensure that the plans would be scientifically defensible and meet program objectives.

There were several important changes and one addition to the HGMPs previously submitted for NMFS review. The proposed LEKT steelhead HGMP (LEKT 2012a) was modified to focus wholly on supportive breeding for Elwha River native winter-run steelhead. Propagation of non-native Chambers Creek-linage steelhead for harvest augmentation purposes was excluded from the proposed action. A new HGMP proposing a supportive breeding program for native Elwha River odd-year and even-year pink salmon (LEKT and WDFW 2012) was added to the submittal.

Another major change was that the HGMPs only covered the preservation and recolonization phases, representing the first two of four phases of salmonid restoration in the Elwha River. The four phases of restoration were derived based on HSRG recommendations and they are defined for the purposes of this opinion as follows (from EMG 2012). First is the preservation phase – the period during and immediately following dam removal when elevated suspended sediment concentrations are expected, at times, to be lethal to fish. The goal during the Preservation Phase is to save or preserve as much genetic and life history diversity as possible until conditions in the river and estuarine systems and the prospects for survival improve. There are no reliable estimates regarding how long the lethal sediment concentrations will persist. The downstream movement of 24 million cubic yards of stored sediment is virtually unprecedented, and subject to numerous variables, primarily weather events.

Following the preservation phase is the recolonization phase. Recolonization begins when the prospects for survival improve and it is prudent to encourage and facilitate more natural spawning. During this phase, the fish have access to refugia from suspended sediment concentrations, or suspended sediment concentrations no longer reach lethal levels. The goal during the recolonization Phase is to ensure that salmonids are continually accessing habitats above the old dam sites with some fish spawning successfully and producing smolts. Again, it is unclear how long this period will last, but its completion is marked by the achievement of numerical goals.

Next, local adaptation is the phase during which (1) sufficient numbers of spawning adults (e.g., meeting or exceeding minimum VSP criteria) are accessing and using newly accessible habitats above the old dam sites, and (2) fish are successfully spawning at a rate that allows for population growth. The goal of the Local Adaptation Phase is to maintain or increase life history diversity of natural spawning populations through local adaptation to the Elwha River ecosystem until minimum levels of spawner abundance, productivity, and distribution are met.

The final phase in fish restoration is the self-sustaining populations phase – the period when all aspects of the previous stages are met and the populations are viable and self-sustaining without any hatchery fish subsidy. The goal of the Self-sustaining Population phase is to ensure that viable and self-sustaining population levels continue once desired values for all VSP and habitat parameters have been met.

This opinion will focus on the preservation and recolonization phases, while including consideration of effects (to the extent possible) in later years. The proposed authorizations would cover the preservation and recolonization phases only, as indicated by the HGMPs, with the LEKT and WDFW required to submit revised HGMPs in advance of any hatchery operations continuing into the local adaptation and full restoration phases of recovery.

These revised and new HGMPs were submitted for NMFS review and 4(d) determination in 2012, and were designed to be consistent with and carry forth population preservation and recovery actions and objectives described in the ERFRP (Ward et al. 2008) over the initial phases of fish restoration. WDFW and LEKT re-submittal of the final plans, separately from the programmatic Puget Sound region-wide ESA hatchery plan effects review and determination process described above, was timely, given initiation of dam removal in September, 2011, and the elevated importance of describing hatchery actions to preserve and restore salmon and steelhead at an enhanced level of detail to ensure that the programs are operated in a manner consistent with the goals and objectives of the EFRP. These updated plans incorporate new scientific information and corresponding adjustments to the proposed actions based on these new data. In addition to adjustments made in response to the most recent HSRG review (HSRG 2012), the HGMPs were revised based on recommendations previously provided by the HSRG through three earlier independent scientific reviews of the plans (HSRG 2002a; 2002b; 2004). The five 2012 co-manager HGMPs for the Elwha River basin describe the proposed programs, actions, and effects evaluated in this opinion for the span of the preservation and recolonization phases of Elwha River fish restoration.

1.3. Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

The proposed actions analyzed in this opinion are: (1) NMFS's determination under limit 6 of the ESA 4(d) rules for listed Puget Sound Chinook salmon and listed Puget Sound steelhead (50 CFR § 223.203(b)(6)) concerning the LEKT and WDFW hatchery programs on the Elwha River; (2) BIA's ongoing disbursement of funds for operation and maintenance of the LEKT hatchery; (3) FWS's disbursement of funds for the operation and maintanence of the hatcheries; and (4) the NPS's participation in funding, authorizations, and other actions in support of the LEKT and WDFW hatchery programs on the Elwha River. Collectively, NMFS, BIA, FWS and NPS are the "Action Agencies." Pursuant to letters received by NMFS from BIA, FWS and NPS, NMFS has been designated as the lead agency for the conduct of this consultation.

The act of funding various hatchery activities does not have an immediate direct effect on listed salmonids. However, there are indirect effects on listed salmonids from the various funding decisions that manifest through the proposed LEKT and WDFW hatchery operations. NMFS finds that the indirect effects of Federal funding are coextensive with the proposed HGMPs. The indirect effects from funding are evaluated and considered below in the context of the NMFS's overall determination under Limit 6.

NMFS describes a hatchery program as a unit of fish propagated for a distinct purpose. The primary objectives of the hatchery programs evaluated in this opinion are to support preservation and recolonization of the existing native salmon and steelhead populations as the Elwha River dams are removed and as the river and associated estuary recover from dam deconstruction effects. The programs follow a spread-the-risk philosophy that promotes both natural production (i.e., putting adult fish upstream of the dams to spawn naturally) and supportive breeding as a hedge against local extinctions. The programs would first help ensure that the remnant native Elwha River salmon and steelhead populations are preserved prior to and during the dam removal period (2007-2014), when stored sediment behind the dams will be released, creating inhospitable conditions for fish in the lower river. For the initial period post-dam removal, the programs would produce juvenile and adult fish with the primary goal of conserving genetic resources as conditions in the lower river and estuary and the prospects for survival improve.

The five proposed hatchery programs carry forth general strategies for preserving and restoring Elwha River salmon and steelhead populations identified in the ERFRP (Ward et al. 2008), the scientific framework guiding efforts to return self-sustaining, natural-origin fish populations to the Elwha River basin. There is precedent for these strategies in the scientific record including the supportive breeding programs for Snake River fall Chinook salmon (NMFS 2012c), White River spring Chinook salmon in Puget Sound, and Snake River sockeye salmon (Ford et al. 2010). Assisting the primary tribal, federal and state agency scientists who assembled the ERFRP were independent scientists, including the HSRG and resource managers representing tribes, state and federal agencies, who provided input in developing the hatchery actions and effects analyses proposed in the ERFRP (Appendix Table 2). Development of the ERFRP, including the selection of native fish populations as the primary populations to be restored, and strategies proposed to recover them, considered the physical constraints of dam removal, biological issues, and specific regional fish management priorities (Ward et al. 2008). Fish preservation and restoration efforts guided by the ERFRP therefore focus primarily on native anadromous salmonids, and propose both natural recolonization and a variety of hatchery-based artificial propagation methods to meet the plan's objectives. Supportive breeding programs for certain populations were identified in the ERFRP as a primary and effective means to compliment natural production and support fish population preservation and restoration objectives. Consistent with the ERFRP, the five hatchery programs are proposed by WDFW and the LEKT for implementation as a means to preserve and restore native Elwha River salmon and steelhead populations before, during, and after removal of the two dams. The HGMPs describe artificial propagation, population recovery objectives, and monitoring and adaptive management needs for each species to meet ERFRP preservation and restoration objectives.

Another effort related to the proposed action is the recovery plan for Puget Sound salmon. Recovery plans under the ESA are intended to serve just this purpose-to identify objective and measureable criteria and provide guidance and actions to accomplish recovery. The Elwha watershed chapter (Volume II) of the Shared Strategy for Puget Sound (SSPS 2007) adopted the 2005 version of the ERFRP and the hatchery programs discussed here in their entirety. The SSPS plan (Ruckelshaus et al. 2005) is the NMFS-approved recovery plan to protect and restore salmon runs across Puget Sound. The SSPS plan engaged local citizens, tribes, technical experts, and policy makers to build a practical, cost-effective recovery plan endorsed by the people living and working in the watersheds of Puget Sound. Supportive breeding actions for the native salmon and steelhead populations provided through the five proposed hatchery programs are intended to be consistent with the SSPS plan for recovering the Elwha population of the Puget Sound Chinook salmon ESU, and the native Elwha River steelhead population that is part of the Puget Sound steelhead DPS.

The supportive breeding programs are designed to be phased out as conditions in the river and estuary and prospects for the survival of each population improves. Consistent with the ERFRP, the phase status would be gauged by monitoring data demonstrating that the natural-origin salmon and steelhead populations were being preserved and recovered, consistent with benchmark population viability parameter levels. Adjustment and phase out of supportive breeding actions would be guided by achievement of specific abundance, diversity, distribution, and productivity goals identified in the "Monitoring and Adaptive Management" section of the ERFRP (Table 2; referenced from Ward et al. 2008). These goals were based on natural fish production potential by species for the restored river, and rebuilding curves derived for Chinook, coho, chum, and pink salmon and for steelhead. In general, the interim goals are defined as abundance levels on a trajectory to long-term recovery goals, natural-origin production in excess of one recruit/spawner, and distribution approximating the historical range of each population (Ward et al. 2008). Under the ERFRP, annual evaluation of the status of each population relative to the interim goals would guide decisions regarding continuation of the hatchery programs.

Specific program adjustment and hatchery program phase-out recommendations were not set in the ERFRP, because recovery of the river and estuary to conditions that would sustain viable natural-origin salmon and steelhead populations, and the productivity responses of the species to dam removal, are highly uncertain. Additionally, each population is likely to respond differently based on its respective life history strategy, starting population size, dependence on lower river habitat or the estuary, and other factors (Ward et al. 2008). The ERFRP serves as a reference for decision makers to consider during the development and implementation of monitoring, evaluation, and adaptive management plans. The plans would be used to identify population viability status of salmon and steelhead in the river as habitat and the natural-origin fish populations recovered to guide fish restoration action responses.

Table 2. Interim restoration targets for Elwha River salmon and steelhead populations propagated by the proposed hatchery programs (Table 25, from Ward et al. 2008).

Species	Abundance		Productivity [a]		Spatial Structure [d]	Diversity	Harvest Goals
	After 10 Years [b]	After 25 Years [c]	After 10 Years	At MSY			
Chinook salmon	~2,000	6,900	>1.0	4.6	Main stem to RM 42.9	Spring and summer/fall	<10 SUS [e] exploitation rate (ER)
Steelhead	~1,500	5,757	>1.0	1.8	Main stem (RM 42.9) and accessible tribs.	Summer/ Winter	<5% (rebuilding)
Coho Salmon	~3,000	12,100	>1.0	2.9	Main stem (RM 42.9) and accessible tribs.	Fall	<40% (rebuilding) <20% (critical) [f]
Fall Chum Salmon	~3,000	18,000	>1.0	2.0	Main stem (RM 16) and accessible tribs.	Fall	<25% (rebuilding)
Pink Salmon	~10,000	96,000	>1.0	2.9	Main stem (RM 16) and accessible tribs.	Early/Late	<50% (rebuilding)

a. Natural-origin recruits and spawners.
b. Abundance of adults spawning naturally, regardless of origin.
c. Abundance of adults of natural-origin spawning naturally.
d. For accessible tributaries, see Hosey and Associates (1988).
e. Southern United States includes fisheries occurring in Puget Sound and off the coasts of Washington, Oregon, and California.
f. Established for all Strait of Juan de Fuca coho salmon populations.

Following on approaches identified in the ERFRP (Ward et al. 2008) and responding to comments provided by the HSRG (HSRG 2012), a scientific work group including federal, tribal and state personnel with specific expertise in Elwha River watershed salmonid population and habitat issues – the Elwha Monitoring Group (EMG) – was formed to develop a list of recommended monitoring and adaptive management actions and stock status parameters that, if implemented, would guide the overall fish restoration, including the proposed supportive breeding programs for listed Chinook salmon and steelhead. The Monitoring and Adaptive Management Plan (MAMP) document assembled by the EMG (EMG 2012) identifies population viability status triggers and habitat condition thresholds for Chinook salmon and steelhead for each of the four restoration phases. The viability status triggers constitute "best science" parameters for gauging the standing of the populations within each of the four restoration phases and to evaluate responsive fish restoration actions proposed for the preservation and recolonization phases in the hatchery plans. These benchmarks identified by the EMG for each species and restoration phase supplant restoration targets originally identified in the ERFRP for Chinook salmon and steelhead (Table 2; Ward et al. 2008).

The MAMP is designed to guide monitoring and adaptive management actions for implementing all salmon and steelhead restoration activities for the Elwha River populations, and as such only certain aspects of the MAMP relate specifically to the proposed action. The MAMP, therefore, is not part of the proposed action, except where the HGMPs specifically adopt measures from the

MAMP. Unless a measure from the MAMP is specifically included in the proposed action by the HGMPs, or is part of the environmental baseline as a result of inclusion in an earlier consultation (e.g., NMFS 2012b), it is not considered reasonably certain to occur and is not relied upon in this opinion.

To that end, the HGMPs included in the proposed action adopt the MAMP viability status triggers (EMG 2012) as a means to inform management decisions up to and including hatchery program termination. For all programs evaluated in this opinion (in particular, the two HGMPs for Chinook salmon (WDFW 2012) and steelhead (LEKT 2012a)), the population viability benchmarks, and adaptive management strategies identified in the EMG document and where incorporated into the HGMPs would guide hatchery production levels and practices during the preservation and natural colonization phases of restoration, and determine the duration of hatchery-based restoration activities proposed for the preservation and recolonization phases. Transition between the preservation, recolonization, and local adaptation phases of fish population restoration in the Elwha River, and responsive changes in supportive breeding strategies to meet listed Chinook salmon and steelhead fish restoration objectives, would be guided by the achievement of population viability parameter triggers defined for the three phases. All of the population viability triggers for a given phase would have to be achieved to transition to the next fish restoration phase. Because all population viability parameters may not exhibit a constant positive trend, if indicators fall below phase triggers, hatchery management actions may revert to the appropriate phase of recovery with associated objectives, protocols, and strategies.

With regards to integration with harvest management, under the ESA-approved Puget Sound Chinook salmon Harvest Resource Management Plan (NMFS 2011b; Harvest RMP - PSTT and WDFW 2011), there will be no directed fisheries harvest of Elwha Chinook salmon. Under the Harvest RMP, the total incidental exploitation rate for Elwha Chinook salmon shall not exceed 10%. This harvest management strategy shall remain in effect until either the Elwha Chinook salmon population recovers or the harvest rate proves to be in excess of the level that will lead to restoration (PSTT and WDFW 2011). Additionally, a five-year moratorium on fisheries in the Elwha River watershed was implemented by the co-managers after the 2011-12 fishing season to provide further protection and assist in the preservation and rebuilding of Elwha River salmon and steelhead. The lone harvest action taking place during the moratorium would be selective fisheries designed to remove the remaining two brood year returns of Chambers Creek-lineage steelhead originating from the now-terminated tribal hatchery program (LEKT 2012a). Fisheries would be terminated after 2014. The fisheries would remove non-native steelhead and reduce threats to natural population genetic diversity.

The individual programs listed in Table 1 will be described in the following section. Included in the descriptions for each program will be the purpose of the program, production goals, program history, and a profile of the facilities, broodstock collection activities, juvenile release strategies, and marking protocols. Research, monitoring, and evaluation activities associated with the five programs and affecting listed natural-origin populations within the Elwha River Basin will also be evaluated.

1.3.1. Elwha Channel Hatchery Chinook Salmon Program

The Elwha Channel Hatchery Chinook salmon program (WDFW 2012) is proposed for implementation over the preservation and recolonization phases of fish restoration. The HGMP includes Elwha Chinook salmon population preservation and restoration objectives specified in the ERFRP for the periods during and after deconstruction of the two Elwha River dams. The goals of the program are to preserve the extant Elwha Chinook salmon population until conditions in the river system and estuary and the prospects for Chinook salmon survival improve and to help initiate recolonization of the watershed through supplementation of the Chinook salmon stock in the basin. The Chinook salmon program uses ESA-listed fish as broodstock, and hatchery-origin progeny produced through the program are included as part of the listed Puget Sound Chinook salmon ESU (64 FR 14308). For the purposes of this opinion, the triggers and thresholds developed by the EMG (2012) for Chinook salmon have been incorporated into the HGMP.

Artificial propagation of the Elwha River Chinook salmon stock to mitigate for placement and operation of the Elwha River dams commenced in 1914, but consistent annual releases of hatchery fish did not begin until 1953. Elwha Channel Hatchery was built in 1974 to function as a spawning channel to enhance Chinook salmon survival. In response to difficulties in attracting adult fish to the site, the facility was modified through construction of ponds to provide for the rearing and on-site release of sub-yearling and yearling Chinook salmon into the Elwha River at RM 3.5. The current program focuses on on-site (hereafter “on-station”) release of sub-yearling and yearling Chinook salmon smolts as the primary strategy. In addition to direct fish releases into the Elwha River, included as a proposed action is the operation of a yearling Chinook salmon rearing and release, and adult broodstock collection facility, on Morse Creek, an eastern Strait of Juan de Fuca tributary adjacent to (eastward) of the Elwha River. The Morse Creek Hatchery program was initiated in 2009 to create an Elwha River-lineage adult Chinook salmon return to Morse Creek that can serve as a genetic reserve and alternative broodstock source in the event of a catastrophic loss of the donor natural- or hatchery-origin components of the population. Under the HGMP, the facility will be operated for up to 12 years, after which time the hatchery infrastructure will be removed and the site will be restored and re-vegetated to its condition before the hatchery was built (WDFW 2012).

The Elwha Channel Hatchery Chinook salmon program has been operated to enhance the survival of Elwha Chinook salmon in response to the degradation and long term (since 1911) blockage at RM 4.9 of natural fish spawning and rearing habitat. Upon dam removal (initiated in September 2011), the program would operate to preserve the Elwha Chinook salmon population when the release of stored sediments creates conditions that are inhospitable to natural-origin fish survival. As conditions in the Elwha and fish survival improves, the program would provide fish to support and accelearate recolonization of the species throughout the basin, including upstream areas rendered inaccessible to anadromous fish for 100 years. The importance of this supportive breeding program is affirmed in a recent analysis of otolith mark recovery data highlighting the dire status of natural-origin Elwha Chinook salmon abundance and productivity. This analysis, included in WDFW (2012), indicates that approximately 95% of adults returning to the river from 2008 to 2010 originated from Elwha hatchery programs, and just 4% were of natural-origin. Monitoring of natural-origin Chinook salmon productivity in the lower Elwha River for two full brood return years (2004 and 2005) shows that emigrant juvenile to returning

Table 3. Population viability parameter triggers used as performance indicators to define the four phases of Elwha River fish restoration, and guide implementation the proposed Elwha Channel Hatchery Chinook salmon program during the preservation and recolonization phases (EMG 2012).

Restoration Phase	**Abundance**			**Productivity**			**Spatial Structure**	**Diversity 2/**	
	Hatchery-origin adult escapement (broodstock)	Natural-origin adult spawning escapement	Proportion Natural Influence (PNI)	Juveniles/ female	R/S (spawner to spawner)	R/S (pre-fishing)		Allele Frequency in Selected Loci	Expected Population Heterozygosity
Preservation	1,700	1,028 (707, 321) 1/	No goal set	200	>1.0 (hatchery+ natural fish)	>1.56 (hatchery+ natural fish)	Some adults spawning above Elwha Dam site	No change	No change
Recolonization	1,700	4,847 (3,333, 1,314) 1/	No goal set	200	>1.0 (for natural fish only)	>1.56 (for natural fish only)	Adults spawning above Elwha Dam and 33% of intrinsic potential	No change	No change
Local Adaptation	500	9,694 (6,664, 3,029) 1/	Work towards PNI = 1.0	200	>1.0 (for natural fish only)	>1.56 (for natural fish only)	Adults spawning above Glines Canyon Dam and 66% of intrinsic potential	Initial decrease, then stable	Initial decrease, then stable
Self-Sustaining Exploitable Population	0	14,688 (10,099, 4,589) 1/	PHOS = 0; PHOB = 0	200	~1.0 (natural fish only)	>~1.85 (natural fish only)	100% of intrinsic potential	Stable, < historical	Stable, < historical

1/ Values in parentheses are numerical components of total escaping adult abundance composed by ocean-type and stream-type origin fish, respectively.

2/ There are two additional indicators of diversity that apply only to the Local Adaptation and Self-Sustaining Exploitable Population phases – proportion of stream type Chinook salmon (yearling migrants returning to spawn) and variation in adult entry timing. For the Local Adaptation phase, a positive trend for both indicators will be the trigger values. For the Self-Sustaining Exploitable Population phase, the population will have stabilized with well-defined early and late run timing and a consistent proportion of the returning spawners each year will have resulted from yearling smolt migrants.

adult survival rates for natural-origin Chinook salmon are extremely low: 0.044% and 0.096%, respectively (WDFW 2012). The two brood years contributed only 63 natural-origin three and four-year old fish to the total escapement to the river in 2008 of 1,153 fish, and 62 four and five-year old adult fish to the 2009 total escapement of 2,181 fish (WDFW 2012). Short term (1995-2009) and longer term growth rates for the Elwha Chinook salmon population were below 1.0: 0.973 and 0.934, respectively (NMFS 2011b).

Hatchery facilities used to implement the Chinook salmon program are Elwha Channel Hatchery (adult trapping, holding, and spawning; and juvenile fish rearing and smolt release); Hurd Creek Hatchery (egg fertilization and incubation through the eyed stage); Sol Duc Hatchery (egg incubation and hatching, fry rearing through fingerling size); and Morse Creek Hatchery (adult trapping, juvenile fish rearing, and yearling smolt release) (Figure 1). The Elwha River mainstem resistance board weir (RBW) on the mainstem Elwha at RM 3.7 and the LEKT's Lower Elwha Fish Hatchery trap also assist the program in the collection of broodstock. Full descriptions of the major facility structures used at each hatchery location to implement the Chinook salmon program are included in the HGMP (WDFW 2012). Elwha Channel Hatchery uses both "surface" (river-sourced) and well water for Chinook salmon production. The City of Port Angeles completed construction of a water treatment facility in 2010 that provides up to 16,000 gallons per minute (gpm) of surface water from the Elwha River for fish rearing and to enhance adult attraction to the hatchery trap. Up to 1,200 gpm of well water is available and used for adult holding, incubation and initial rearing. Surface and well water use at Elwha Channel Hatchery is permitted under Washington Department of Ecology (WDOE) water right permit # G2-29018. Effluent discharge from the hatchery is monitored and reported consistent with WDOE guidelines, in compliance with National Pollutant Discharge Elimination System (NPDES) permit #WAG13-1043. Groundwater at Hurd Creek Hatchery is supplied by five wells (capacity 2,000 gpm) under WDOE water right permit #02-24026, and is used for incubating Elwha River Chinook salmon eggs through the eyed life stage. Hurd Creek surface water is also available as an emergency back-up supply. Hurd Creek Hatchery produces a relatively small amount of fish each year, and well under the 20,000 pounds per year criteria set by WDOE as the limit for concern regarding hatchery effluent discharge effects. Fish production at Hurd Creek is below the maximal annual poundage production level for which an NPDES permit and attendant effluent monitoring are required. Sol Duc Hatchery uses gravity-fed spring water for both incubation and initial rearing of Elwha Chinook salmon under WDOE water right permit #S2-21118. Effluent discharge and monitoring at Sol Duc Hatchery is regulated under WDOE NPDES permit #WAG13-1045. The yearling program at Morse Creek Hatchery relies on pumps in Morse Creek that provide 1,600 to 2,400 gpm for fish rearing under WDOE (water right permit #S2-30527). Morse Creek has a 1,350- square foot fiberglass pollution abatement pond to treat water used to rear fish prior to its discharge back into Morse Creek, consistent with WDOE NPDES permit #WAG 13-1013 requirements.

The hatchery broodstock sustaining the program is derived from the natural-origin Elwha Chinook salmon population collected as returning adults from the Elwha River. Chinook salmon populations in the Elwha River historically displayed a wide range of life history strategies that took advantage of diverse natural habitat conditions present in the river in its pristine state, prior to construction of the dams (Ward et al. 2008). The current population no longer exhibits this life history diversity. Primarily as a result of dam construction and operation, adult fish entry and spawning dates have shifted to the late summer and fall over time and are reduced in the extent of their duration. Between 1953 and 1994, the Elwha River remained one of the few places in Puget Sound where the native Chinook salmon return was used to sustain hatchery production, without substantial transfers of exogenous stocks (e.g. Green River lineage fish) (WDFW unpublished data, 1998). Over this period, Elwha Chinook salmon provided 91% of adult fish used for spawning. From 1995 through 2010, all Chinook salmon adults used as broodstock were collected from the Elwha River for spawning. As noted previously, first generation hatchery-origin adult fish now make up most of the annual adult return to the Elwha River. Considering long-standing blockage of the main-stem river limiting natural production, and operation of the hatchery program consistent with proposed production levels since 1976, broodstock collection operations for the past 20-30 years have likely incorporated predominantly first-generation hatchery-origin fish, with natural-origin fish accounting for a low proportion of the totals. Remaining components of the historical populations have been retained in what is now believed to be a single population through natural spawning and hatchery enhancement activities. The hatchery- and natural-origin components of the Elwha River population are genetically indistinguishable and are thought to represent what remains of the genetically unique and independent Elwha Chinook salmon population (NMFS 2004b; Ruckelshaus et al. 2006).

Broodstock currently used for the hatchery program are hatchery-origin adult fish volunteering to the hatchery weirs, and natural- and hatchery-origin fish randomly collected from the run-at-large returning to the mainstem Elwha River (WDFW 2012). Broodstock collection would occur at several locations and using several methods: 1) beach seining at two specific adult holding areas on the Elwha River mainstem; 2) capture of adult fish returning to the Elwha Spawning Channel side-channel weir and trap at RM 3.5; 3) gaffing of spawning adults on the river; 4) gill netting at specific adult holding areas on the Elwha River (used in the past for adult collection); 5) capture of adult fish at the resistance board weir installed in 2010 on the mainstem Elwha at RM 3.7; 6) capture of adult fish volunteering to the LEKT Lower Elwha Hatchery ladder and trap; and, 7) capture of adult fish returning to the Morse Creek Hatchery weir and trap. As discussed above, the removal of adult Chinook salmon from the river for use as hatchery broodstock was previously authorized by NMFS (NMFS 2006a, NMFS 2012b). That take is included in the environmental baseline for this opinion. Removal of Chinook salmon from the river for use as broodstock was required as a term and condition as a means to reduce take levels of listed Chinook salmon that would result from the effects of removal of the Elwha dams (NMFS 2006a):

> "The NPS shall rescue and remove adult salmon from the Elwha River and move to the WDFW rearing channel, the Lower Elwha Klallam Tribes fish hatchery, or to unaffected river habitat above Lake Mills to reduce the level of take from sediment releases. NPS shall monitor to ensure that the Elwha River Chinook salmon population will be sustained by meeting target broodstock collection for hatchery augmentation during high sediment years. Assuming a 50 to 50 sex ratio, target numbers to maximize hatchery output is 1,835 adults. NPS shall implement strategies consistent with the Elwha River Fish Restoration Plan (Ward et al., 2008) if this target number cannot be achieved and will notify the NMFS, Washington State Office, Lacey, Washington of these actions by December 1 of each year, as appropriate" (NMFS 2006a)."

Under the proposed action, annual broodstock collection requirements have been reduced from 1,835 adults specified in the NMFS (2006a) consultation, to 1,700 adults because juvenile fish production numbers and egg take requirements, have been reduced for the program since 2006. Therefore, to meet the juvenile fish production goal for the proposed program, up to 1,700 adults would be collected for hatchery broodstock each year, representative of the origin (hatchery, natural) and timing of the annual run-at-large adult return to the Elwha River. This collection level assumes a 10% pre-spawning mortality (high range), a 50:50 sex ratio, and a fecundity of 4,600 eggs per female. From 1999 through 2009, the average number of adult fish collected as broodstock was 1,052 fish (range 667 to 1,553 fish) (WDFW 2012). Annual adult fish collection activities would span the breadth of the summer and early fall periods when Chinook salmon return to the Elwha River (September 15 peak, August through October annual adult return duration).

Adult Chinook salmon would be collected from the Elwha River fish using the above methods, and either spawned at the collection locations, or transported to Elwha Channel Hatchery for holding through spawning. Eggs would be collected for fertilization in three- or four-fish pools, depending upon the volume of the eggs. Milt would be collected in one-fish units (no pooling), in plastic bags with oxygen. Although some fertilization may take place at Elwha Channel Hatchery, most eggs and milt collected would be iced and transported to Hurd Creek Hatchery, where eggs would be fertilized in a "modified factorial" design, where each bucket of pooled eggs would be split into three to four aliquots, depending upon the number of females, and each aliquot of eggs would be fertilized with sperm from one male. The eggs would then be recombined and placed into isolation incubation units for water hardening in iodophor and incubation until virus-free fish health certification is completed. Eggs would be incubated at Hurd Creek Hatchery through the eyed stage, at which time they would be transported to WDFW's Sol Duc Hatchery for incubation through hatching and rearing to the fingerling life stage. Fingerlings would be reared at Sol Duc Hatchery until February, when they would be transported to Elwha Channel Hatchery for rearing and release as either sub-yearling or yearling smolts. Fish destined for release at Morse Creek Hatchery as yearlings would be transferred into the facility from Sol Due Hatchery as fingerlings in mid-October.

The proposed annual juvenile fish release goal for the program is 2,500,000 sub-yearlings (released on-station at RM 3.5) and 400,000 yearlings. Of the yearlings, 200,000 would be released each year into the Elwha River at RM 3.5, and 200,000 would be released into Morse Creek at RM 1.0 from Morse Creek Hatchery. The sub-yearlings would be released into the Elwha River in June at an average individual size of 80 fish per pound (fpp), and yearlings would be released in April at a size of 10 fpp. Yearling fish would be released into Morse Creek from Morse Creek Hatchery in mid-April each year at a size of 10 fpp.

The 1999 through 2011 average annual number of sub-yearling Chinook salmon released into the Elwha River through the program was 2,671,404 fish (range 926,000 to 4,025,000 fish) (WDFW 2012). Annual yearling releases into the Elwha River averaged 193,464 fish (2004-2011 range 72,400 to 318,150 fish). Elwha stock yearling Chinook salmon releases into Morse Creek began in 2005, and annual releases through 2011 (excluding "0" releases in 2009) have averaged 184,205 fish (range 106,100 to 208,000 fish). Other hatchery Chinook salmon fish release locations, fish life stage release types, and fish release abundance levels are described in the ERFRP for the pre-, during, and post-dam removal phases (Ward et al. 2008, Table 6). The HGMP also allows for optional release strategies, dependent on annual adult return abundances, to reduce risk and promote spatial distribution of the Chinook salmon population. These additional strategies would be collection and upstream transport of adult fish returning to the lower river to allow the fish to spawn naturally; planting of eyed eggs in upstream locations; and, out-planting of Chinook salmon fry, sub-yearling smolts, and yearling smolts in upstream locations (Ward et al. 2008). Under the HGMP, the lower river collection, upstream transport, and release above the dam sites of aggregate hatchery- and natural-origin adult Elwha Chinook salmon to allow the fish to spawn naturally would be the priority strategy among off-station release options during the preservation and recolonization phases (WDFW 2012). Off-station releases of other Chinook salmon life stages would be considered for implementation, and evaluated through a separate ESA consultation, in response to data indicating that upstream releases of adult fish, and spontaneous recolonization by returning Chinook salmon alone, were not achieving the goals for population viability during the population restoration phase (Table 3).

Until recently, Chinook salmon hatchery releases have been unmarked and untagged. Beginning in 2003, some fish were adipose fin-clipped and coded-wire tagged (CWT), or adipose-fin clipped, ventral fin clipped, and CWT. Beginning with the 2010 brood year releases and continuing through the present, all Chinook salmon released through the program were otolith marked (sub-yearlings) or otolith marked and blank wire tagged (yearlings). All Chinook salmon released from Elwha Channel Hatchery are currently marked or tagged mark to differentiate hatchery- from natural-origin Chinook salmon and allow for assessments of hatchery program performance and effects.

Under the HGMP, beginning with brood year 2012 (release year 2013), 250,000 of the 2,500,000 subyearlings released through the program would be adipose-clipped and CWT-tagged. The purpose for this marking approach would be to learn where and how many Elwha Chinook salmon (hatchery and natural-origin alike) are caught in ocean fisheries, including the potential reduction in escapement resulting from mark-selective fisheries.

Beginning no earlier than brood year 2015, WDFW proposes to mass mark all subyearlings released each year through the program with an adipose fin clip, and discontinue otolith marking. Howver, adipose clipping of all subyearlings may be delayed if sediment levels in the river remain high, natural production is low, it is judged unlikely that broodstock management will be initiated with the adult return of the 2015 brood of subyearling Chinook, and analysis of CWT recoveries indicates a substantially higher mortality rate of clipped Chinook salmon in mark-selective fisheries than projected by FRAM. Assuming that adipose clipping is initiated with the 2015 brood of subyearling Chinook, the benefits of adipose clipping will begin in 2018 with the return of 3 year old fish, and by 2020 essentially all hatchery returns will be clipped. This timing is intended to correspond to the period when turbidity has decreased, estimated at up to 5 years post dam removal (WDFW 2012).

Beginning no earlier than brood year 2014, all yearling releases of Elwha River Chinook salmon would be adipose clipped at a 100% rate, while otolith marking would be discontinued. As with the subyearling mass-mark proposal, adipose clipping of all yearlings may be delayed if sediment levels in the river remain high, natural production is low, it is judged unlikely that broodstock management will be initiated with the adult return of the 2015 brood of subyearling Chinook, and analysis of CWT recoveries indicates a substantially higher mortality rate of clipped Chinook salmon in mark-selective fisheries than projected by FRAM.

WDFW proposes to apply an adipose fin clip to juvenile Chinook salmon as proposed to begin to efficiently identify the hatchery or natural origin of fish. The purpose of an adipose fin clip would be to aid in implementing broodstock management principals intended to reduce hatchery influence in the naturally spawning population, with the goal of developing a self-sustaining locally adapted stock (WDFW 2012); a need assumed to start during the local adaptation phase of restoration. They also propose that fisheries harvest impacts on the total abundance of Elwha Chinook salmon escaping to spawn would not be substantial as a consequence of marking all hatchery fish with an adipose fin clip, and that any added low abundance risk to the Elwha Chinook salmon population created by a reduction in returning hatchery-origin adults form fisheries harvest would decrease as natural Chinook salmon production in recovering habitat increases. Under the HGMP, as proposed for implementation during the preservation and recolonization phases of restoration, there is no proposal to use the adipose fin clip mark as a means to manage the proportion of hatchery-origin Chinook salmon spawning naturally or the proportion of hatchery and natural-origin fish incorporated as hatchery broodstock (WDFW 2012).

1.3.2. Lower Elwha Native Steelhead Program

The Lower Elwha Native Steelhead Program would propagate native Elwha River winter-run steelhead for preservation and recolonization purposes (LEKT 2012a). The program would operate until habitat begins to return to a properly functioning condition and the prospects for steelhead survival improve. Specifically, the program would conserve Elwha steelhead genetic resources while its habitat is disrupted by dam removal and promote recolonization of the restored watershed as the lower river and estuary recover from dam removal effects. The program would use the ESA-listed Elwha River steelhead for broodstock. Hatchery-origin progeny produced through the program are included as part of the listed Puget Sound steelhead DPS (72 FR 26722, May 11, 2007) (Jones 2011). The program would be implemented and adjusted over the preservation and recolonization phases of restoration. The intent to gauge the status of program progress within these phases based on the triggers and thresholds developed by the EMG for steelhead (EMG 2012; Table 4) is referenced (LEKT 2012a).

The native steelhead population, that would be the focus of the supportive breeding program, is at a critically low abundance level and the population is further affected by unprecedented (for the Elwha) sediment transport and turbidity levels that is currently making habitat in the lower watershed inhospitable for natural fish survival and production.

Artificial propagation of the native Elwha River winter-run steelhead population began in 2006 (2005 brood year) with the collection of eggs from redds created by naturally spawning steelhead for the purposes of creating a captive broodstock. These fish had not previously been in artificial propagation. Under the HGMP, eggs or fry would be collected from the Elwha River for up to twelve consecutive brood years (2005 – 2016) as a donor source for captive broodstock maintained at the LEKT's Lower Elwha Fish Hatchery. The first progeny of captive broodstock

Table 4. Population viability parameter triggers used as performance indicators to define the four phases of Elwha River fish restoration, and guide implementation of the proposed Lower Elwha Fish Hatchery steelhead program during the preservation and recolonization phases (EMG 2012).

Restoration Phase	**Abundance 1/**			**Productivity 1/**			**Spatial Structure**	**Diversity**		
	Hatchery-origin adult escapement (broodstk)	Natural-origin adult spawning escapement	Proportion Natural Influence (PNI)	Juveniles/ female	R/S (spawner to spawner)	R/S (pre-fishing)	-	Allele Frequency in Selected Loci	Entry Timing Diversity	Expected Population Heterozygosity
Preservation	300	500	No goal set	75	>1.0 (hatchery + natural fish)	>1.0 (hatchery + natural fish)	Some adults spawning above Elwha Dam site – 7.5% Intrinsic Potential	No change from baseline	Average entry date observed for first four years of restoration	No change from baseline
Re-colonization	300	969	No goal set	75	>1.0 (for natural fish only)	>1.56 (for natural fish only)	Adults spawning above Elwha Dam and 37% of intrinsic potential	No change from baseline	Avg 50% run timing changes at a rate of 0.5 days per year; fish returning in February	No change from baseline
Local Adaptation	0	1,938	PNI = 0.76 PNOS = 0.24	75	>1.0 (for natural fish only)	>1.85 (for natural fish only)	Adults spawning above Glines Canyon Dam and 74% of intrinsic potential	Initial decrease, then stable	Avg 50% run timing changes at a rate of 0.5 days per year fish returning in January	Initial decrease, then stable
Self-Sustaining	0	2,619	PNI = 1.0 PNOS = 1.0	75	~1.0 (for natural fish only)	>1.85 (for natural fish only)	100% of intrinsic potential	No decrease from previous phase	Avg 50% run timing changes at a rate of 0.5 days per year; fish returning in December	No decrease from previous phase

1/ Spawner escapement (Abundance) and productivity trend (Productivity) triggers delineated for each restoration phase must be achieved for 4 years for transition to the next restoration phase.

native steelhead grown to adult size and spawned were released as smolts into the Elwha River from Lower Elwha Hatchery at RM 1.3 in spring, 2011. The last smolts that are progeny of captive broodstock steelhead would be released into the river in 2018. The first adult fish produced through the program are expected to return to the Elwha River in 2013. In the five-year period following dam removal, when natural spawning success is expected to be constrained by sediment transport and unstable channels, the intent is to capture all native, adult steelhead that return, and incorporate them into program broodstock. The program would continue to use captive-reared broodstock until returns from released smolts, and natural-origin adults returns, provide adequate broodstock. The strategy would then transition from a wholly captive broodstock-based approach to supplementation using returning adult steelhead as broodstock as adult returns to the river build after 2013.

Lower Elwha Fish Hatchery, located on the right bank of the Elwha River at RM 1.25, is where all phases of the proposed native stock hatchery steelhead program would occur (Figure 1). Artificial propagation actions at the hatchery include captive broodstock rearing; adult trapping, holding, and spawning; egg incubation and hatching; juvenile fish rearing to smolt size; and fish release (on-station or upstream transport). Full descriptions of the major facility structures used at the hatchery location to implement the native steelhead program are included in the HGMP (LEKT 2012a).

Water supplied for fish production at Lower Elwha Hatchery is from a mix of surface and ground water sources. Water quality is similar in condition to ambient water in the Elwha River, but the hatchery water temperature profile is relatively cooler during the summer and warmer during the winter due to the influence of the ground water component. Surface water is collected from a diversion facility located at RM 3.2 of the Elwha River that supplies up to 29 CFS to the hatchery. Water delivered from the diversion structure may receive treatment to strip sediment from the surface water delivered to the hatchery. The goal of treatment for sediment removal is to maintain a maximum surface water turbidity of 20 NTUs. A total of 4,000 gpm ground water is supplied by six on-site wells. Well water delivered to the hatchery is de-gassed prior to use in fish rearing units at the hatchery. Effluent discharge from the hatchery is monitored and reported consistent with EPA guidelines, in compliance with NPDES permit# WAG13-0023.

The broodstock used in the program is derived directly from the existing, naturally spawning native Elwha River winter-run steelhead population. Establishment of the hatchery broodstock began in 2006 with collection of eyed eggs and/or emergent fry from redds produced by late-returning 2005 BY Elwha River steelhead. Egg/fry collection from redds was conducted annually through the 2010 BY (2011 collection year). Juvenile fish retained for the program as captive broodstock undergo genetic testing to verify their native-stock lineage.. The average proportion of hatchery broodstock comprised of naturally spawning, late returning steelhead for these initial years of operation was 100%. The captive brood production and total steelhead spawning objectives for the program are based on the phase of dam removal: during dam removal (2012 – 2016) – 350 adults from captive brood, supplemented with adults collected from the river; post-removal (post 2017) - 350 adults per year from returning hatchery fish, incorporating an as yet-to-be determined percentage of natural-origin adults (<50 fish) subject to prioritizing natural-spawning in restored river habitat (as per Ward et al. 2008 and LEKT 2012a).

To meet broodstock needs for the supplementation portion of the program, the tribe would collect steelhead that return to Lower Elwha Fish Hatchery from previous years' on-station captive broodstock-origin smolt releases. Initial returns from the captive broodstock program are expected in winter, 2013-2014. Natural-origin adults used as broodstock would be provided through fish captures at the resistance board weir on the mainstem Elwha River at RM 3.7 or fish collected using opportunistic beach seining, gill-netting, or hook and line in the lower river. The annual number of returning, native steelhead eggs, fry, and adults collected for use as broodstock from the Elwha River or from fish returning to Lower Elwha Hatchery will vary, as determined by the phase of the program (dam removal or post dam removal), broodstock survival and egg production levels, and the abundance status of adult fish returns to the river (Tables 10 and 11, Ward et al. 2008). Prior to dam removal (brood years 2010-2012) annual broodstock collection reflected the intent to collect eggs from redds, or use captive reared-adults sufficient to maintain stocks prior to that period of time during which upstream adult access past the dam sites is possible. During the dam removal and surmised extreme lower river disturbance period (2012 - 2015) the goal of adult collection is to capture as many returning natural-origin adults as feasible (total return is approximately 200 fish (LEKT 2012a), under the assumption that their potential to spawn successfully will be substantially reduced due to high sediment transport and resultant inhospitable conditions in the river. Starting in 2013, between 200 and 500 adult hatchery-origin fish returning as a result of the native steelhead supplementation effort would also be collected for use as broodstock during the dam removal period. Following dam removal, in 2016 adult collections of returning hatchery-origin adults would increase (to 500+), consistent with ERFRP schedules, and collection of natural-origin steelhead would decrease (to <50 fish). During and after dam removal, collection of natural-origin broodstock will be supplemented with captive-reared adults. The removal of adult steelhead from the river for use as hatchery broodstock was analyzed by NMFSin the 2012 biological opinion concluding a reinitiated ESA section 7 consultation with NPS for implementation of "Elwha River Ecosystem and Fisheries Restoration Project," and incidental take was exempted in an accompanying incidental take statement (NMFS 2012a). These effects are included in the environmental baseline in this opinion.

To support the production of captive broodstock steelhead, eyed eggs and emergent fry would be collected from redds created by native winter-run steelhead in the lower Elwha River. Embryonic development of eggs post-spawn are tracked and redds are sampled following eye-up to minimize risk of mortality to developing embryos upon their removal from the redds. Only a small portion of each red would be sampled (limit of 250 eggs or alevins per redd). Eggs and emergent fry would be taken from multiple redd sites throughout the lower river area accessible to natural spawners. All eggs and fish incorporated into the hatchery program are of native steelhead origin, as indicated in genetic parental lineage analyses. Eggs removed from redds would be incubated and hatched at Lower Elwha Hatchery, and resultant fry would be reared to age-4 adulthood in raceways at the hatchery. Further details regarding techniques applied to identify and monitor native steelhead redds, and remove eyed eggs for use as captive broodstock, are included in the ERFRP (page 42 in Ward et al. 2008).

Adult steelhead produced through the captive broodstock program or captured from adult returns to Lower Elwha Hatchery or to the Elwha River would be held through maturation and spawned at Lower Elwha Hatchery. When captive brood steelhead reach age 3, they would be assessed for sexual maturity. Maturation status of female fish would be determined manually. Ovulating females would be stripped, segregated from males, and returned to raceways for reconditioning and a final year of rearing. Beginning in March, the ovulatory status of 4 year old females would be assessed on a weekly basis. Females found to be ovulating would be isolated for mating. Captive broodstock program-origin steelhead would be selected for spawning randomly from ripe fish on a given day. The genetic origin of ripe females would be determined by scanning of PIT tags (all juvenile captive broodstock fish are genetically identified and receive a PIT tag) to determine fish identity and to identify appropriate mates. Mating guidelines and spawning matrices would include: crossing each female with three males; ensuring that each female is genetically unique from each of the three males; ensuring that each male spawned is genetically unique from other males in a given mating; and limiting the use of each male for mating to three times during the spawning season. Females would be spawned individually, and eggs would be divided into three aliquots. Eggs would be rinsed with a buffered sodium bicarbonate solution to remove debris and promote sperm motility. After the rinse solution is removed, each aliquot would receive sperm from one of the three males. Water would be added to initiate sperm motility and eggs are recombined into a single incubation lot. Fertilized eggs would then be loaded into vertical tray incubators and allowed to water-harden for 60 minutes in 3 liters of 100 PPM buffered PVP iodine solution. Following water-hardening, the eggs would be incubated at Lower Elwha Hatchery in Heath-style stacks at 3 gpm inflow from the groundwater source, so that no siltation occurs during the incubation process.

Eggs would be incubated in discrete lots, sequestered by origin (redd, captive brood, returning adult). Incubating egg development is monitored on a weekly basis. Eyed eggs would be shocked, sorted to remove non-viable eggs, inventoried, and retrayed prior to hatching in Heath trays with a triple-layer of Vexar screening to inhibit coagulated yolk condition. After hatching, steelhead fry would be transferred to, and maintained sequentially in fiberglass rearing troughs and concrete raceways during residence at the hatchery. Flow-based and volume-based loading criteria would be maintained throughout the rearing period to ensure that fish densities are consistent with fish health maintenance criteria. Steelhead that are to be maintained as captive broodstock would be sampled genetically when they reach a size of 100 mm (fork length (fl)). Tissue samples collected from each fish would be genetically analyzed to assess parental lineage. The steelhead would then receive a surgically implanted PIT tag that will identify the fish for the duration of residence at the hatchery. Steelhead destined for release into the Elwha River through the supplementation portion of the program would be reared for two years in raceways at Lower Elwha Hatchery, and released into the Elwha River as 2-year-old smolts.

The health of steelhead propagated through the proposed program would be monitored and managed throughout the rearing period consistent with Co-manager Fish Health Policy practices (NWIFC and WDFW 1998). Professional fish pathologists from the NWIFC Tribal Fish Health Center would visit the hatchery monthly, or as needed, to perform routine monitoring of juvenile fish, advise hatchery staff on disease findings, and recommend disease treatments when appropriate. NWIFC staff also provides fish disease pathogen vaccinations for use in Tribal fish production programs.

The production target for the program is 300 captive broodstock adult steelhead each year for twelve years (2005-2016). The proposed annual on-site juvenile fish production goal for the supplementation portion of the program would be 175,000 age-2 smolts volitionally released into the Elwha River as migration-ready fish at RM 1.3. Smolts would be released in March or April at an average size of 5 fpp. This is a new program (the native stock has not been previously artificially propagated), and 2011 was the first year that smolts from the program have been released. In March 2011, 170,000 2-year-old native stock steelhead smolts were released from Lower Elwha Fish Hatchery into the Elwha River at RM 1.3.

Consistent with the ERFRP schedule and in addition to the primary on-station smolt release actions described in the proposed HGMP, the native steelhead preservation and restoration approach may include several alternative strategies. Implementation of these alternative strategies would be dependent on annual adult native steelhead return levels relative to population viability triggers defined in the EMG plan for steelhead (Table 4 - EMG 2012) and the results of the primary supportive breeding strategy of on-station smolt releases. These additional strategies are: collection from the lower river and upstream transport and release of returning adult native steelhead to allow the fish to spawn naturally in lower and mid-basin areas unaffected by dam removal actions; planting of eyed eggs in upstream locations; and, out-planting of steelhead fry, pre-smolts, and 2-year old smolts in upstream locations (Ward et al. 2008). Under the proposed plan, the LEKT would potentially out-plant up to 100,000 eyed eggs, 275,000 fry, 20,000 pre-smolts, and 25,000 smolts into appropriate rearing habitat in the lower and mid-basin (LEKT 2012a).

Consistent with the ERFRP schedules, the number of native adult steelhead captured, transported and released upstream to spawn naturally would range from 37 fish, when the total native steelhead escapement is 500 to 1,000 fish, to 4,537 fish, when adult escapements to the river exceeds 5,000 (Tables 10 and 11 in Ward et al., 2008). Under the HGMP, the lower river collection, upstream transport, and release above the dam sites of aggregate hatchery- and natural-origin adult, native-stock, winter-run steelhead to allow the fish to spawn naturally would be the highest priority off-station hatchery strategy for supporting native steelhead production during the preservation and recolonization phases (LEKT 2012a).

All native steelhead propagated and released into the natural environment through the program would receive a coded wire tag, potentially combined with an otolith mark applied thermally and/or a PIT tag. Initially, none of the fish would be marked with an adipose fin clip, as a measure to differentiate the fish from the last remaining early returning (Chambers Creek hatchery-lineage) adult steelhead. The production of Chambers Creek steelhead was terminated in 2011 and the last adult returns from the program will be in 2014. Starting with brood year 2013, a proportion or all steelhead produced through the program would be adipose fin-clipped. All hatchery broodstock (captive, and collected from returns to the river) would be genotyped, allowing parentage-based tagging of adult steelhead and their progeny for later assessment of relative reproductive success and relative survival.

As noted previously, a five-year harvest moratorium on fisheries in the Elwha River watershed was implemented by the co-managers after the 2011-12 fishing season and extending through 2017 to provide further protection and assist in the preservation and rebuilding of Elwha River salmon and steelhead populations during and immediately after the dam removal phase. The lone harvest action proposed during this moratorium period would be implementation of tribal ceremonial, subsistence, and commercial fisheries in 2012-2013 and 2013-2014 to remove remaining 2009 and 2010 brood year adult returns of Chambers Creek-lineage steelhead originating from the now-terminated LEKT Chambers steelhead programk (LEKT 2012a: 2012d). This focused fishing activity to remove escaping adipose fin-clipped, non-native steelhead would be conducted as a genetic risk reduction measure to further reduce threats to the native winter-run steelhead population. The impacts of fisheries in the Elwha River directed at the removal of Chambers Creek-lineage steelhead were previously evaluated and authorized by NMFS through a separate ESA consultation and a determination pursuant to Limit 6 of the 4(d) rule (NMFS 2011b). The effects identified in that determination are included in the environmental baseline of this opinion. In implementing the fishery (over two seasons), the LEKT has proposed to further limit incidental harvest effects on listed Elwha River steelhead from those authorized by NMFS (2011b). The tribe would reduce the incidental harvest rate on the native Elwha River steelhead population from the 10%-12% (NMFS 2011b) to 4% or less of the total escaping wild population.

NMFS has received a harvest plan from the LEKT for review under the 4(d) regulations. The plan proposes a small harvest of hatchery-origin steelhead, starting no sooner than 2018. The proposal states that after this time and when the abundance of natural-origin returning adult winter steelhead exceeds 200, the Tribe would take up to 50 hatchery-origin adults from the same returning population. No sooner than 2020, if the natural-origin returns increase to over 300, the Tribe could harvest up to 200 hatchery-origin fish. This plan is not part of the proposed action – its consideration by NMFS under the 4(d) rules will be a future federal action – but its implementation is related to the abundance increases intended by the LEKT steelhead hatchery program. Therefore, its effects will be briefly discussed in section 2.4.

1.3.3. Lower Elwha Fish Hatchery Coho Salmon Program

The Lower Elwha Fish Hatchery Elwha River Coho Salmon Program (LEKT 2012b) would propagate coho salmon for preservation and restoration purposes during and after the Elwha dam removal phases. The stock propagated through the program is the extant coho salmon population native to the Elwha River. The primary, initial goals of this program are to preserve and rebuild natural coho salmon production in the Elwha River by supplementing the abundance of juvenile and returning adult fish (LEKT 2012b). The hatchery program would be used to maintain the genetic characteristics of the native coho salmon stock during the dam removal phase and as habitat in the lower river and estuary recovers from high sediment loads released as the dams are removed. Post dam-removal, the program would be used to promote re-colonization of suitable coho salmon spawning and rearing habitat throughout watershed areas accessible to the species. ERFRP interim restoration benchmarks for Elwha River coho salmon are achievement of terminal area abundances of 3,000 fish after ten years, and 12,100 fish after 25 years, with productivity (spawner recruits per parent spawner) of natural-origin fish exceeding 1.0 (Table 2). The program has an integrated recovery intent (LEKT 2012b).

Consistent with the ERFRP (Ward et al. 2008), the program would be operated to restore healthy, natural coho salmon production in the Elwha River watershed following the removal of hydroelectric dams on the Elwha River mainstem. The viability of natural-origin coho salmon has been adversely affected by the dams. Natural coho salmon production has been confined to the degraded mainstem area and tributaries downstream of Elwha Dam (RM 4.9) for 100 years, and hatchery-origin coho salmon have comprised the majority of annual returns to the river for at least four decades. Although the quantity and quality of available habitat will be gradually restored when the Elwha and Glines Canyon dams are completely removed in 2014, coho spawning and rearing habitats will be affected in the short term by high sediment transport, channel instability, and reduced water quality resulting from dam removal and the release of stored sediments. The hatchery program would help preserve the Elwha River coho salmon population through the period of dam removal and river channel stabilization. Production from the program would focus on release of yearling smolts on-station to supplement total adult returns, and the upstream transport and release of adult coho salmon in mid- and upper-basin tributaries to promote re-colonization of the watershed, and optimize coho salmon utilization of the high-quality habitat made accessible by dam removal.

The coho salmon population in the Elwha River is part of the Puget Sound/Strait of Georgia coho salmon ESU (Weitkamp et al 1995). ESA listing of the ESU was determined by NMFS to be not warranted on July 25, 1995 (60 FR 38011), but the ESU was classified as a Species of Concern on April 15, 2004, because of specific risk factors (69 FR 19975). A subsequent petition to list Puget Sound coho salmon was determined to not present substantial evidence to indicate that the petitioned action was warranted (75 FR 38776, July 6, 2010).

The Lower Elwha Fish Hatchery is where all phases of the proposed hatchery coho salmon program would occur. Artificial propagation actions at the hatchery would include adult trapping, holding, and spawning; egg incubation and hatching; juvenile fish rearing to smolt size; on-station fish release at RM 1.3; and transport of adult fish for upstream release, consistent with ERFRP schedules. Full descriptions of the major facility structures used at the hatchery location to implement the program are included in the coho salmon HGMP (LEKT 2012c).

Summary information regarding water sources, water quality, and effluent discharge permits for fish production at Lower Elwha Hatchery is presented in the previous section for the Lower Elwha Fish Hatchery Elwha River Native Steelhead program (LEKT 2012a).

The coho salmon program at Lower Elwha Fish Hatchery was founded in 1978 through collection and spawning of the native Elwha River coho salmon population (LEKT 2012b). Juvenile fish production is currently sustained through annual returns of adult coho salmon to the hatchery rack or to the lower river. The precise number of natural fish incorporated into the hatchery program annually since its inception is unknown. However scale pattern analysis has shown that in recent years no natural–origin fish have been spawned at the hatchery. Although no natural-origin coho salmon are currently incorporated as broodstock for the program, there are no known differences between the natural spawning and hatchery populations and run timing between the two populations has remained identical. Adult coho salmon are collected for use as broodstock from October through early December. Hatchery-origin coho salmon collected as broodstock can be differentiated from natural-origin fish because all coho salmon produced by the program receive one or more of the following marks or tags: otolith mark (thermally induced), adipose fin clip, coded wire tag, or PIT tag.

Broodstock used for the program would be adult coho salmon volitionally returning to the adult capture facility located at Lower Elwha Fish Hatchery. Returning adult fish are collected and spawned across the breadth of the total run period to insure representation of all timing portions of the coho salmon run. Eggs taken in excess of production goals are culled proportionally through all egg take lots. All fish returning to the hatchery facility are included in egg-take operations. The broodstock collection goal for the program to meet ERFRP-recommended juvenile and adult fish production schedules during and post-dam removal is 400-600 adult fish. The recent 10-year (2001-2010) average number of adult coho salmon returning to the hatchery and available for use as broodstock was 2,921 fish (range 218 to 5,749 fish). A portion of the adult fish collected in excess of hatchery production needs each year would be transported upstream for release into the upper Elwha River watershed to spawn naturally, consistent with ERFRP-recommended schedules. Adult fish not needed for spawning or upstream planting would be sacrificed at the hatchery, sampled for coded wire tags, and either used for tribal cultural (subsistence) programs, donated to local food banks, or distributed in the Elwha River watershed for nutrient enrichment purposes.

Mature adult coho salmon would be selected randomly for spawning from the population held at the hatchery. Males would be used only once for spawning. Precocious males (jacks) would be used at a rate equivalent to 3 to 5% of the total males retained in the spawning program. If data are available, jacks would instead be incorporated at the rate that they are observed in the returning population. Eggs removed from females would be pooled in 20 female lots. Eggs from the 20 lots would be randomly mixed and then divided into 14 sub-lots. Males would be spawned and sperm held separately for each fish. Sperm from two males (one principal, one back-up) would be added to each of the 14 lots of eggs and mixed. After fertilization, the eggs would be loaded into vertical tray incubators and allowed to water-harden. Next, the eggs would be incubated through eye-up and hatching at flows of 3.0 gpm. Extra eggs would be collected to make up for mortalities during incubation and rearing and to ensure that the egg take proportionately represents all segments of the run timing spectrum. Surplus eggs would be either destroyed or would be sold to egg brokers for export overseas. Any coho salmon fry in excess of program needs would be destroyed to avoid exceeding programmed fish production levels. After swim-up, fry would be transferred to raceways for initial rearing in late January or early February. Fry would be reared to fingerling and yearling smolt size in progressively larger raceways at the hatchery using surface and groundwater supplies previously described for the Lower Elwha Fish Hatchery in Section 1.3.2.

The health of coho salmon reared at the hatchery would be monitored and managed throughout the rearing period consistent with Co-manager Fish Health Policy practices (NWIFC and WDFW 1998). Professional fish pathologists from the NWIFC Tribal Fish Health Center would visit the hatchery monthly, or as needed to perform routine monitoring of juvenile fish, advise hatchery staff on disease findings, and recommend disease treatments when appropriate. NWIFC staff would also provide fish disease pathogen vaccinations for use in Tribal fish production programs.

The proposed annual on-site juvenile fish production goal for the program would be 425,000 yearling smolts volitionally released on-station into the Elwha River at RM 1.3. The smolts would be released in mid-May each year at an average size of 16 fpp. The release timing was chosen to reduce potential ecological interactions with emigrating natural-origin chum and pink salmon fry, and with hatchery-origin Chinook salmon sub-yearlings released in June from

WDFW's Elwha Channel Hatchery program. The average number of smolts released in recent years (1999 – 2009) was 469,791 fish (range 175,380 to 724,594 fish). Upstream coho salmon enhancement activities proposed during the preservation and recolonization phases would include the transport and release of adult fish returning to the hatchery to augment natural spawning. The hatchery program would assure persistence of the coho population through the period of dam removal and channel stabilization.

Recovery would be the primary objective of the hatchery program during the initial phases of restoration. If warranted, based on monitoring and evaluation results, the hatchery fish release strategy would be adjusted to promote geographic distribution of fish throughout suitable spawning habitat in the watershed by the release from the hatchery of yearling smolts and through the transport and release of returning adults into suitable habitat in the watershed.

Hatchery production of coho salmon would also support fishing opportunities in the river as the recolonization, local adaptation and self-sustaining phases of coho recovery occur. The effects of coho salmon-directed fisheries in the Elwha River on listed fish have been previously evaluated and authorized by NMFS through a separate ESA consultation (NMFS 2011b). Coho salmon fisheries in the Elwha River are not part of the proposed actions considered in this opinion. The supportive breeding aspect of the program would be phased out in response to achievement of natural-origin coho salmon population restoration objectives and specific population viability targets (Ward et al. 2008). The general plan for the program specifies that coho salmon hatchery production would be terminated in 20 years, or when the 5-year running average of the aggregate natural- and hatchery-origin terminal area coho salmon run exceeds 10,000 fish (LEKT 2012c).

To allow for their differentiation from naturally produced coho salmon, prior to their release from the hatchery all coho salmon would receive one of the following marks or tags: otolith mark induced thermally; adipose fin clip; coded wire tag; PIT tag; or a combination of these marks or tags.

1.3.4. Lower Elwha Fish Hatchery Chum Salmon Program

The Lower Elwha Fish Hatchery Elwha River Chum Salmon Program (LEKT 2012c) would propagate fall-run chum salmon for preservation and restoration purposes during and after Elwha dam removal. The stock propagated through the program is the extant, fall-timed chum salmon population in the Elwha River. The primary initial goals for the program are to preserve and rebuild natural fall chum salmon production in the Elwha River by supplementing the abundance of juvenile and returning adult fish (LEKT 2012c). The hatchery program would be used to maintain the genetic characteristics of the current chum salmon stock during the dam removal phase and as habitat in the lower river and estuary recovers from high sediment loads released as the dams are removed. Post dam-removal, the program is intended to promote re-colonization of suitable chum salmon spawning and rearing habitat throughout watershed areas accessible to the species. ERFRP interim restoration benchmarks for Elwha River chum salmon are achievement of terminal area abundances of 3,000 fish after ten years, and 18,000 after 25 years, with productivity (spawner recruits per parent spawner) of natural-origin fish exceeding 1.0 (Table 2).

Consistent with the ERFRP (Ward et al. 2008), the program would be operated to restore healthy, natural fall chum salmon production in the Elwha River watershed following the removal of the two dams on the Elwha River. Like other anadromous fish species remaining in the river, the viability status of natural-origin fall chum salmon has been adversely affected through limitation of production to the reach below Elwha Dam for 100 years. The dams have made the river inhospitable to chum salmon and other anadromous salmon species through freshwater and estuarine habitat degradation, and blockage of upstream migration at RM 4.9. The quantity and quality of available habitat will be gradually restored after the Elwha and Glines Canyon dams are completely removed in 2014. However, chum salmon spawning and rearing habitat conditions will continue to be adversely affected for a period of time after the dams are gone by high sediment transport and reduced water quality caused by release of stored sediments and resulting river channel and riverbed instability.

The hatchery program would help assure persistence of the stock through the periods of dam removal and river channel stabilization. The hatchery would release fed fry on-station to supplement adult returns as the primary supportive breeding strategy. Consistent with ERFRP production schedules (Tables 16 and 17 in Ward et al., 2008), the program would also transport returning adult fish upstream to spawn naturally in areas unaffected by dam removal activities. Pending evaluations of the success of on-station fry release and upstream adult transport in meeting adult fish return objectives, alternative hatchery strategies may also include the out-planting of eggs and fry in mid- and upper-basin tributaries to promote re-colonization of the watershed and optimize fall chum salmon use of the high-quality habitat made accessible by dam removal.

The fall chum salmon population in the Elwha River is part of the Puget Sound/Strait of Georgia chum salmon ESU (Johnson et al. 1997). The ESU includes all naturally spawned populations of chum salmon from Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca up to and including the Elwha River, with the exception of summer-run chum salmon from Hood Canal and the Strait of Juan de Fuca. After reviewing the status of chum salmon populations in the ESU, NMFS determined that ESA listing of the ESU was not warranted on August 10, 1998 (63 FR 11774).

Lower Elwha Fish Hatchery is where all phases of the proposed hatchery chum salmon program would occur. Artificial propagation actions at the hatchery would include adult trapping, holding, and spawning; egg incubation and hatching; juvenile fish rearing to fed fry size; on-station fish release at RM 1.3; and transport of eyed eggs, fry, and adult fish for upstream release, consistent with ERFRP schedules (Table 16 and 17 in Ward et al. 2008). Full descriptions of the major facility structures used at the hatchery location to implement the program are included in the chum salmon HGMP (LEKT 2012c).

Summary information regarding water sources, water quality, and effluent discharge permits for fish production at Lower Elwha Hatchery is presented in the previous section for the Lower Elwha Fish Hatchery Elwha River Native Steelhead program (LEKT 2012a).

The chum salmon program was founded in 1994 to maintain the genetic legacy of the native stock through supportive breeding including out-planting unfed fry through egg box releases and (beginning in 2005) on-station releases of fed fry (LEKT 2012c). In response to the need to rebuild critically depressed natural abundance levels in the watershed (Hiss 1995), chum salmon production at Lower Elwha Fish Hatchery is currently sustained by the collection of fall chum salmon adults for use as broodstock from the lower Elwha River, and from returns of adult chum salmon to the hatchery rack. In 2011, adult fish straying into the Elwha Channel Hatchery trap (presumably to escape high sediment loads in the Elwha River mainstem) were also collected for use as broodstock. Natural-origin chum salmon, collected from the Elwha River mainstem and tributaries, have been the sole source of broodstock for the program. There are no known differences between the natural spawning and hatchery populations and run timing for the two aggregations has remained identical. Adult fall chum salmon collected as broodstock enter the Elwha River in November and December.

Broodstock are collected from the Elwha River using gill nets and beach seines. Adults collected from the river exhibit the historical run timing of the native fall chum stock. Beginning in 2015, adult chum salmon returns to the Lower Elwha Fish Hatchery trap resulting from on-station fry releases will sustain the program, precluding the need to capture adult fish from the river. Gametes will be taken from all adult chum salmon returning to the hatchery facility each year. The hatchery would collect and spawn fish representative of the entire chum salmon return period to reduce the risk of run timing divergence from the natural population.

The annual broodstock collection goal for the program is 1,000 adult fish during dam removal and 800 adult fish for the post dam removal period. These goals are consistent with broodstock numbers needed to meet ERFRP juvenile and adult fish production schedules for theduring and post-dam removal periods (Tables 16 and 17 in Ward et al. 2008). The annual number of fall chum salmon collected as l broodstock for the period 2001-2010 averaged 28 fish (range 0 to 66 fish). Fish in excess of broodstock needs will be put to other uses and not returned to the river to spawn naturally. All chum salmon collected for broodstock would be sacrificed at the hatchery, sampled for biological information and otolith marks, and either used for tribal cultural (subsistence) programs, donated to local food banks, or distributed in the Elwha River watershed for nutrient enrichment purposes.

Mature adult chum salmon would be selected randomly for spawning from the population held at the hatchery. Eggs removed from females would be pooled in 20 lots. Eggs from these lots would be randomly mixed and then divided into 14 sub-lots. Males would be spawned and sperm held separately for each fish. Sperm from two males (one principal, one back-up) would be added to each of the 14 lots of eggs and mixed. After fertilization, the eggs would be loaded into vertical tray incubators and allowed to water-harden. Following water-hardening, the eggs would be incubated through eye-up and hatching at flows of 3.0 gpm. Because of the depressed abundance of fall chum salmon in the Elwha River, there would be surplus eggs taken each year, and all eggs collected would be incubated and used to achieve program goals. After swim-up, fry would be transferred to raceways for initial rearing in late December or early January. Fry would be reared to a release size of 450 fpp (~56 mm fl) in raceways at the hatchery using surface and groundwater supplies previously described for the Lower Elwha Fish Hatchery in Section 1.3.2.

The health of chum salmon reared at the hatchery would be monitored and managed throughout the rearing period consistent with Co-manager Fish Health Policy practices (NWIFC and WDFW 1998). Professional fish pathologists from the NWIFC Tribal Fish Health Center would visit the hatchery monthly, or as needed to perform routine monitoring of juvenile fish, advise hatchery staff on disease findings, and recommend disease treatments when appropriate. NWIFC staff would also provide fish disease pathogen vaccinations for use in Tribal fish production programs.

The annual chum salmon fry release goals are 450,000 fish during the preservation phase, and 450,000 to 1,025,000 fish during the recolonization phase. All juvenile fish will be volitionally released directly from Lower Elwha Fish Hatchery into the Elwha River as migration-ready fish at RM 1.3. The fry would be released in March through April each year at an average size of 450 fpp. Chum salmon fry releases from the hatchery would be timed to match the natural egression time for natural-origin Elwha River fall chum salmon as documented by Peters (1996). The planned release timing is also designed to reduce their interaction with emigrating coho salmon (late March through mid-May - Peters 1996) and with Chinook salmon smolts released from the WDFW's Elwha Channel Hatchery (mid-June to late June – WDFW 2012). Average annual release numbers for the period 2001-2009 were 8,809 fed fry (range 0 to 31,290 fish) and 24,356 unfed fry (range 0 to 59,149 fish). Hatchery enhancement of chum salmon will be phased out in response to increases in natural-origin spawning as the natural chum salmon population begins to achieve self-sustainability (Ward et al. 2008) and meets restoration targets (Table 1). Total releases of chum salmon and specific life history stages at which releases would occur are detailed in the ERFRP (Ward et al. 2008). As adult chum salmon returns to the river increase towards recovery objectives, the number of fry released through the program may be adjusted downward, and the number of adults released upstream increased to promote natural recolonization (LEKT 2012c).

To allow for their differentiation from naturally produced chum salmon, prior to their release from the hatchery, all chum salmon would receive a thermally induced otolith mark applied during incubation.

1.3.5. Elwha River Pink Salmon Preservation and Restoration Program

The Elwha River Pink Salmon Preservation and Restoration Program (LEKT and WDFW 2012) would propagate native stock-origin odd-year and even-year pink salmon for preservation and restoration purposes during and after the Elwha dam removal phases. The goal for odd-year pink salmon is to bolster the abundances of emigrating juvenile and returning adult fish to restore self-sustaining natural-origin populations that maintain the genetic characteristics of the native stock, and return at annual adult return abundances approaching estimated historical levels. For even-year pink salmon, the program is intended to preserve the population through the dam removal period, after which it will be terminated to allow the population to naturally recolonize the Elwha River when it becomes accessible to migrating anadromous salmonids above river mile 4.9 (post 2014) (LEKT 2011e). The pink salmon program has an integrated recovery intent for both populations.

The proposed program would reduce the risk of extirpation for both pink salmon races during the dam removal period. The supportive breeding approach would preserve remaining Elwha River odd-year and even-year pink salmon populations, and enhance their survival after the dams are removed and as habitat in the lower river recovers. Recommended ERFRP interim restoration benchmarks for odd-year pink salmon are a terminal area abundances of approximately 10,000 fish after ten years, and 96,000 fish after 25 years, with productivity (spawner recruits per parent spawner) of natural-origin fish exceeding 1.0 (Table 2). The odd-year program would use supplementation and a captive broodstock program to meet those population recovery objectives. The objective for the even-year pink salmon population is to simply preserve it at its current, low abundance level, thereafter allowing the fish race the opportunity to recolonize the Elwha River naturally. A short-term preservation and supplementation program only is planned for even year pink salmon to achieve this objective during the Elwha dam removal phase.

Both pink salmon populations have been driven to very low abundances due primarily to blockage and degradation of historically available natural spawning habitat beginning in the early 1900s. Pink salmon were thought to once be the most abundant salmonid species in the watershed, and likely of great importance to the Elwha River ecosystem (Pess et al. 2008). Construction of two dams without fish passage facilities on the Elwha River in 1912 and 1925 directly reduced accessible habitat for anadromous salmonids by 90% (DOI 1996), resulting in the immediate decline of several up-river life history types including pink salmon (Pess et al. 2008).

The appearance of a genetically unique, low-abundance odd-year population between 1991 and 1999 renewed hope that the species could be recovered in the Elwha River. With annual escapements of less than100 fish, Elwha River pink salmon are in trouble (WDF et al. 1993; Pess et al. 2008; M. McHenry, unpublished LEKT survey data, 2010). The pink salmon population was described by WDFW (2002) as a wild stock whose origin is unknown. Recent year Elwha River pink salmon abundance levels have been extremely low, and it is uncertain whether the population is self-sustaining (Pess et al. 2008). Odd-year pink salmon escapement indices have ranged from approximately 200 in 2001 to less than 40 in 2009, with even-year pink salmon escapements estimated to be under 20 fish during that period (LEKT and WDFW 2012). Although the quantity and quality of available habitat for pink salmon production will be gradually restored, after the Elwha and Glines Canyon dams are removed, both races of the population will be threatened with extirpation over the short term by inhospitable water quality and sedimentation conditions.

Creation of a captive broodstock using the extant odd- year population, and implementation of a supplementation program using both stocks as donors, will preserve the stocks during the dam removal phase, circumventing lower river migration, spawning and incubation conditions that will substantially prevent natural production. Juvenile fish would be released to the river as viable (fed) fry after short-term rearing. The captive broodstock program for the odd-year stock would transition, after one or two brood years, into a supplementation program to bolster pink salmon abundance during the recolonization phase of restoration. The objective of the program during this latter phase would be to improve the status of the population and increase the likelihood that it could be restored to an abundance near estimated historical levels.

On-station fry releases would be the primary supportive breeding strategy, and upstream transport and release of adult fish would be the secondary strategy during the preservation phase. Consistent with ERFRP-recommended production schedules (Tables 19 and 20 in Ward et al., 2008) and pending results in meeting preservation and recolonization objectives from implementation of these two strategies, the program could also produce eggs and fry for outplanting in mid- and upper-basin tributaries to promote re-colonization of the watershed, and optimize pink salmon use of the high-quality habitat made accessible by dam removal. After dam removal and as natural habitat and pink salmon population viability recover, supplementation of the odd-year aggregation would cease entirely.

One difficulty affecting the pace of natural population recovery is that the pink salmon are unlikely to colonize the majority of habitats throughout the Elwha River made available through dam removal (Pess et al. 2008). Historically, the longitudinal extent of pink salmon spawning was restricted to reaches up to RM 16 (Winter and Crain 2008). Pink salmon may be limited in ability to colonize areas upstream of RM 16 due to the species limited ability relative to other salmonid species to swim over natural barriers. The critically low abundance of the current population also will not likely encourage spawning out of the currently accessible lower river spawning areas, and upstream into historically used reaches.

The odd and even year pink salmon populations in the Elwha River are included as part of the Washington Odd and Puget Sound Even Year Pink Salmon ESUs, respectively (Hard et al. 1996). NMFS reviewed the status of Elwha River and other Washington-origin pink salmon in response to a March, 1994 petition to list the species as protected under the ESA. Based on this review, NMFS determined that ESA listing for the two ESUs and their component populations, including Elwha, was not warranted (60 FR 192, October 4, 1995). However, both Elwha River populations are at a critically low abundance status, and are in danger of extirpation (WDFW 2002; LEKT and WDFW 2012).

The Lower Elwha Fish Hatchery is where nearly all phases of the supportive breeding portion of the program would occur. Supportive breeding actions at the hatchery would include adult trapping, holding, and spawning; egg incubation and hatching; juvenile fish rearing to fed fry size; on-station fish release at RM 1.3; and transport of adult fish for upstream release, consistent with ERFRP schedules. The mainstem weir located at RM 3.7 and opportunistic capture of fish using gill nets and purse seines throughout the lower river would assist in the collection of broodstock for the entire program. Effects on listed Chinook salmon and steelhead occurring incidentally during broodstock collection have been authorized by NMFS through a separate ESA consultation (NMFS 2012a).

The captive broodstock portion of the program would occur primarily at NMFS's Manchester Research Station, located on central western Puget Sound near the town of Manchester, Washington. Actions taking place at Manchester would include rearing of transferred fed fry to two-year-old adult size and maturity, and transfer of mature adult fish to Lower Elwha Fish Hatchery for spawning. Full descriptions of the major facility structures used at the hatchery locations to implement the program are included in the pink salmon HGMP (LEKT and WDFW 2012). Pink salmon fry reared in the captive broodstock program would come from WDFW's Hurd Creek Hatchery, where pink salmon transferred from Lower Elwha Fish Hatchery are reared to the fed fry life stage.

Summary information regarding water sources, water quality, and effluent discharge permits for fish production at Lower Elwha Hatchery is presented in the previous section for the Lower Elwha Fish Hatchery Elwha River Native Steelhead program (LEKT 2012a). Manchester

Research Station is supplied with a constant source of processed seawater to rear seawater-tolerant pink salmon fry to adult size. Annual seawater temperature at the site normally ranges between 7-15°C and salinity ranges between 28-30 ppt. A 60 hp centrifugal pump supplies approximately 1,500 gpm of seawater through a 2,100 foot long pipeline from the east end of a pier at the facility to the station's land based facilities. The seawater supplied to the station is processed to prevent naturally occurring bacterial pathogens and parasites from entering the rearing tanks. Primary filtering consists of six deep-bed fiberglass sand filters that remove all materials greater than 20 microns in diameter, and a portion of smaller materials. Immediately after leaving the sand filters, the seawater enters two filter systems, which contain a total of 148 cartridge filters ensuring a filtration of materials no greater than 5 microns. To control for pathogens, the filtered seawater then passes through stainless steel UV chambers where the water is UV-irradiated. After UV filtration, seawater is supplied directly to fish rearing tanks.

This is a new program, and there have been no previous attempts to artificially propagate native Elwha River pink salmon for release into the Elwha River. The initial year of operation for the pink salmon program was 2011, when odd-year adult fish were collected as broodstock from returns to the Elwha River. Under the proposed action, adult odd- and even-year pink salmon broodstock would be collected from the Elwha River in August and September each year. For odd year fish, pink salmon grown to adult size through the captive broodstock portion of the program would also be used as broodstock.

Broodstock used for the program would be collected from the run-at-large trapped at the mainstem RBW at RM 3.7, and through captures of fish using gill nets and beach seines. Beginning in 2013, adult pink salmon returns to the Lower Elwha Fish Hatchery trap, resulting from on-station fry releases, will help sustain the program. Also beginning in 2013, captive broodstock pink salmon will supplement egg takes from adult returns to the river. Gametes will be taken from all pink salmon adults available each year. Fish representative of the entire pink salmon return period would be collected and retained for spawning to reduce the risk of run timing divergence from the extant natural populations, and exclusion of remaining diversity in the critically depressed, remnant populations.

The annual number of pink salmon adults collected for use as broodstock would vary, as determined by: the phase of the program (preservation v. recolonization); captive broodstock survival and egg production levels; and, the abundance status of adult fish returns to the river (Table 5).

For the initial two years of operation (2011-2012), the annual broodstock collection goal for each pink salmon populationd reflects the intent to collect as many returning adult fish to the river as feasible. The annual number of adult fish collected in each of these years would assume that total adult returns remain at or below the recent year maximum estimated abundance of 200 fish. For 2013, the odd-year adult broodstock collection goal of 200 would be decreased based on the adult equivalent abundance of eggs available through the captive broodstock program. Adult fish would still be collected from the river spawning with captive broodstock fish (proportion of natural origin fish in the broodstock, pNOB, will be 20%). Even-year pink salmon broodstock

Table 5. Annual Elwha River Pink salmon broodstock collection levels.

Return Year	Number of Adult Fish	Broodstock Use
2011& 2012	200	Seed odd year captive broodstock and odd/even supplementation programs
2013 & 2014	Up to 200	Seed odd year captive broodstock and odd/even supplementation programs
2015 & 2017	500	Seed last brood year of odd year captive broodstock program, and support odd year supplementation program
2019 & 2021	3,000	Support odd year supplementation program

collection for 2014 would take as many returning adult fish as feasible. No even-year pink salmon would be collected for use as hatchery broodstock after 2014. For 2015 and 2017, with initial and continuing supportive breeding program-origin adult returns, up to 500 odd year adult fish would be collected each year as a means to augment captive broodstock production, reduce divergence between the captive and "wild" returning aggregations, and to meet supportive breeding program fry release objectives.

The odd year program would transition to a supplementation-only effort commensurate with phase-out after 2013 brood year adult contributions from the captive broodstock program in 2015. Thereafter, the number of broodstock collected from adult returns to the watershed each year would reflect egg take needs required to support the annual release of 3,000,000 fed fry into the Elwha River (Table 6). Production of this number of fed fry would necessitate collection of 3,000 adult fish, assuming 80% green egg to fed fry survival, a 1:1 sex ratio for the adult return and an average fecundity of 1,600 per female (range 1,000 to 2,100). The recent 10 Year (2001-2010) average number of adult chum salmon collected for broodstock was 28 fish (range 0 to 66 fish). Fish collected in excess of hatchery production needs would be transported upstream and released to spawn naturally in areas of the watershed unaffected by dam removal activities.

Mature adult pink salmon would be selected randomly for spawning from the population held at the hatchery. Eggs removed from females would be pooled in 20 lots. Eggs from these lots would be randomly mixed and then divided into 14 sub-lots. Males would be spawned and sperm would be held separately for each fish. Sperm from two males (one principal, one back-up) would be added to each of the 14 lots of eggs and mixed. After fertilization, the eggs would be loaded into vertical tray incubators and allowed to water-harden. Following water-hardening, the eggs would be incubated through eye-up and hatching at flows of 3.0 gpm. Because of the critically depressed abundance status of pink salmon in the Elwha River, there would be surplus eggs taken each year, and all eggs collected would be incubated and used to achieve program goals. After swim-up, fry produced through the supportive breeding program would be transferred to raceways at Lower Elwha Fish Hatchery for initial rearing in late December or early January. Fry would be reared to a release size of 450 fpp in raceways at the hatchery using surface and groundwater supplies previously described for the Lower Elwha Fish Hatchery in

Table 6. Annual number of Elwha River odd year pink salmon juveniles retained for the captive broodstock (CB) program at the Manchester Research Station and number released as fed fry from Lower Elwha Hatchery for supplementation (Supp) purposes.

Brood Year	Production Location	Annual Level
2011	Manchester Facility Lower Elwha Hatchery	1,000-2,000 (CB) 158,000 (Supp)
2013	Manchester Facility Lower Elwha Hatchery	1,000-2,000 (CB) 958,000 (Supp)
2015	Manchester Facility Lower Elwha Hatchery	1,000-2,000 (CB)[1] 1,200,000 (Supp)
2017, 2019, 2021	Manchester Facility Lower Elwha Hatchery	0 (CB) 3,000,000 (Supp)

[1] Up to 2,000 pink salmon juveniles will be retained for captive broodstock rearing through the 2015 brood year, after which time the program will transition to supplementation only.

Section 1.3.2. A representative portion of the total number of eyed eggs from each egg take date (family) produced each year would be transferred to Hurd Creek Hatchery for incubation and hatching to produce fry to seed the Manchester captive broodstock program.

The health of fish reared through the program would be monitored and managed throughout all life phases under propagation consistent with Co-manager Fish Health Policy practices (NWIFC and WDFW 1998). Professional fish pathologists from the NWIFC Tribal Fish Health Center would visit the hatchery facilities monthly, or as needed to perform routine monitoring of juvenile fish, advise hatchery staff on disease findings, and recommend disease treatments when appropriate. NWIFC staff would also provide fish disease pathogen vaccinations for use in the fish production programs.

Fry would be released in March and April each year at 450 fpp (range 400 to 800 fpp). Pink salmon fry releases into the Elwha River would be timed to match the known natural emigration timing for Elwha River pink salmon. Fry releases during this period would also reduce their interaction with (and potential predation by) newly released hatchery coho salmon (May release) and with subyearling Chinook salmon smolts released from the WDFW’s Elwha Channel Hatchery (mid to late June). In 2012, approximately 40,000 fed fry, the progeny fish captured at the RBW in 2011, were released into the Elwha River. Consistent with ERFRP-recommended production schedules, (Tables 19 and 20 in Ward et al., 2008), returning adult pink salmon produced through the program and additional pink salmon eggs and fry above on-station release goals, may be out-planted into areas of the Elwha River basin upstream of the Lower Elwha Fish Hatchery. Upstream pink salmon enhancement activities would include upstream transport and release of adult fish returning to the hatchery to augment natural spawning, and potentially, the release of fed fry and eyed eggs in streamside incubator boxes located in side-channel habitats to imprint the pink salmon to river areas suitable for natural pink salmon production. Hatchery enhancement of pink salmon will be phased out in response to increases in natural-origin spawning as the natural-origin odd-year pink salmon population begins to achieve self-sustainability and meets restoration targets (Table 1; Ward et al. 2008).

To allow for their differentiation from naturally produced pink salmon, prior to their release from the hatchery, all pink salmon would receive a thermally induced otolith mark, applied during incubation.

1.3.6. Monitoring, Evaluation, and Research Activities

As the original scientific framework for the HGMPs, the ERFRP (Ward et al. 2008), identifies how to monitor and evaluate performance of the programs and achievement in meeting salmon and steelhead population preservation and restoration objectives. Monitoring and evaluation objectives associated with hatchery fish production in the watershed are: (1) evaluate recolonization by species (or genotype) and method of reintroduction through the examination of rebuilding rates (production), population size (abundance), spatial distribution, and habitat utilization; (2) document the genetic structure and life history diversity of existing Elwha River fish populations, and identify how genetic structure and life history diversity are affected by dam removal and hatchery practices over time; document how any changes affect the viability of the population; (3) monitor fish health over time, space, and method of reintroduction; and, (4) document recovery of ecosystem processes over time and space, including not only the freshwater ecosystem, but also riparian, nearshore, and terrestrial habitats. Hypotheses have been developed for each of these four primary objectives to specify desired or expected outcomes of the recovery plan requiring implementation of monitoring, evaluation, and research actions (Table 7).

Table 7. Monitoring and evaluation objectives for Elwha hatchery programs and testable hypotheses addressing achievement of the objectives.

Objective	Hypotheses
Recolonization	*Spatial distribution* - Rate of dispersion throughout the watershed is consistent with modeled and expected rate; species are utilizing all physically appropriate and accessible habitat; and no barriers to migration exist. *Composition of spawning population* - Success of reintroduction methods is consistent with expectations; and composition of spawning population is consistent with expectations. *Productivity and abundance* - Rate of recovery is consistent with modeled or expected rate; juvenile NOR production is consistent with rebuilding rate expectations; and hatchery-origin fish post-release survival is consistent with expectations.
Genetic Diversity and Population Integrity	*Run timing and spawn timing* - run timing and spawn timing are not changing over time. *Genetic composition* - actions implemented under the plan do not directly alter the genetic signature of remaining populations. *Phenotypic composition* - phenotypic composition is not changing over time.
Fish Health Response	Restoration strategy has not introduced, transferred, or amplified fish diseases in the watershed.
Ecosystem Recovery	The ecosystem is recovering to historical or expected conditions; and, recovery rate is consistent with expectations.

Source: Ward et al. 2008

Subsequent to completion of the ERFRP, the MAMP developed by the EMG (EMG 2012) for Chinook salmon and steelhead identified comprehensive sets of monitoring and evaluation actions that, if implemented, would determine the viability status of these listed species relative to triggers developed by the group for each restoration phase.

The MAMPs are not being implemented through the proposed action, as discussed above. However, the Chinook salmon and steelhead HGMPs have identified monitoring, evaluation, and research objectives and actions specific for listed species under propagation that are incorporated into their plans and that would be used to address the objectives and hypotheses in Table 7. These actions would complement and/or augment the core monitoring actions from the EMG MAMP previously identified by NMFS as necessary to adequately assess listed Chinook salmon and steelhead population viability status and hatchery program performance effects in the previously-approved NPS dam removal action (NMFS 2012a). All of the HGMPs identify objectives and actions needed to determine hatchery program performance in meeting stated preservation, restoration, and/or production objectives for the specific species that are the focus of each HGMP (HGMP sections 1.10), and effects on target and non-target natural-origin fish populations in the Elwha River watershed. The results of monitoring and evaluation actions required by NMFS in its dam deconstruction consultation with NPS (NMFS 2012a) can be used to indicate progress of the HGMPs in meeting program performance and effects objectives.

Monitoring and evaluation actions for the WDFW Elwha Channel Hatchery Chinook salmon program are summarized in Section 1.10 of the plan (WDFW 2012). Specific monitoring and evaluation actions for the four LEKT HGMPs are described in section 11.0 of each hatchery plan (LEKT 2012a; 2012b; 2012c; LEKT and WDFW 2012). Monitoring and evaluation actions, in certain instances partially or wholly funded as part of the NPS dam removal action (NMFS 2012a), would include operation of weirs (at the Elwha Channel and Lower Elwha Fish hatcheries, and on the Elwha River mainstem at RM 3.7); operation of juvenile outmigrant traps to collect fish for identification of species, origin, and biological characteristics; foot and boat surveys to census salmon and steelhead spawning abundance and to sample carcasses to identify fish origin; monitoring and reporting of fish harvests by species and by origin; monitoring of broodstock collection, egg take, and smolt release levels for each program; fish health monitoring and reporting; genetic analysis of naturally produced smolts, and un-marked adults to measure the extent of genetic exchange between hatchery-origin and natural-origin fish; and other activities needed to determine hatchery program effects and performance.

Spawning ground surveys above and below the mainstem Elwha weir to assess the abundance (numbers of adults or redds) and origin (hatchery or natural) of each species escaping to spawn naturally, and the distribution of spawning, are part of the dam deconstruction proposed action (NMFS 2012a). The effects of these surveys on listed fish have therefore been previously evaluated and authorized by NMFS through a separate consultation, and are included in the environmental baseline of this opinion.

Operation of a juvenile out-migrant monitoring program to assess natural- and hatchery-origin salmon and steelhead abundance and migrational behavior (seasonal timing, migration rate, and migration duration) is an essential component of the research and monitoring needed to identify listed species survival and productivity during the fish restoration effort and overlap in timing between natural-origin species and newly released hatchery-origin fish. To meet this research and monitoring need, the LEKT, assisted by the NMFS Northwest Fisheries Science Center (NWFSC) and the Northwest Indian Fisheries Commission (NWIFC), operates a rotary screw-trap each year in the Elwha River at RM 0.6 to monitor juvenile salmon and steelhead outmigration timing and abundance. In addition to abuncance and migration timing data, fish size, origin (marked/tagged vs., unmarked/untagged) and other biological data (e.g., tissue samples for genetic analyses) would be collected. Stomach contents would also be collected from subsamples of captured juveniles to determine fish diets during emigration. The trap would operate from February to July each year. To ensure proper care and maintenance of trapped fish as a means to minimize take of listed fish, the trap would be sampled frequently to reduce holding duration, and trapping would be suspended during high flow events to reduce the risk of fish injury and mortality. Other risk aversion measures that would be implemented to minimize take in tribal monitoring, evaluation, and research activities are specified in annual NMFS 4(d) Evaluation and Determination documents authorizing such activities (e.g., NMFS 2009).

The LEKT receives annual authorization for the take of listed fish species at the rotary screw trap operation through a separate ESA consultation process that includes evaluation of the effects of all research, monitoring and evaluation programs operated by the treaty tribes in the Puget Sound region (NMFS 2009). The tribe deploys the screw trap each year in the lower Elwha River to assess juvenile salmon and steelhead outmigrant abundance, timing and size. The trap is primarily used to assess natural salmon and steelhead outmigrantion, and is therefore a separate actions from the hatchery-related actions proposed in the HGMPs. The Puget Sound tribes, including LEKT, provide estimates to NMFS Protected Resources Division each year of the maximum annual number of listed juvenile Chinook salmon and steelhead by origin that would be captured, handled, sampled, and released through the proposed trapping program. Anticipated take levels are evaluated for effects at the population and ESU/DPS levels, and a determination is made under the 4(d) Rule research limit whether the actions are sufficiently conservative to warrant exception from section 9 take prohibitions. Because the LEKT rotary screw trap program is evaluated and authorized for ESA compliance through another consultation process, the program is in the environmental baseline with respect to past operations and will be the subject of separate approval for future operations.

As noted previously, operation of adult salmon and steelhead weirs in the Elwha River Basin, and resultant listed fish take levels, have also been previously evaluated and authorized through separate NMFS ESA consultations (NMFS 2006a; NMFS 2010b; NMFS 2012a). Takes of listed Chinook salmon, steelhead, and eulachon occurring through operation of the mainstem Elwha River weir (including operation of a DIDSON[1] system and tissue sampling for genetic analyses) and at hatchery weirs to collect data to meet listed salmon and steelhead abundance, distribution, and origin objectives specified as primary monitoring needs in the HGMPs have therefore already been addressed by NMFS for listed fish effects and their monitoring and evaluation effects are included in the environmental baseline of this opinion.

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[1] Dual-Frequency Identification Sonar, a sonar technology that allows for video-like inspection and identification of objects underwater.

Other hatchery-related monitoring and evaluation actions included in the HGMPs that have not been previously evaluated for listed fish effects, and that will be implemented with the weirs and juvenile out-migrant trapping programs to meet objectives in Table 7, would include (from WDFW 2012; LEKT 2012a):

- Counting and sampling (scale, mark/tag and/or otolith) and identification of age class distribution and sex ratio of adults returning to the hatcheries and escaping to spawn naturally to assess fish species status and origin;
- Tissue sampling and genotyping of adult Chinook salmon and steelhead returning to the hatchery and of carcasses recovered in natural spawning areas to enable evaluation of hatchery program genetic diversity effects and parentage analysis-based estimation of total escapement;
- Marking and/or tagging of all fish released through the hatchery programs to allow for assessment of hatchery-origin adult contributions to total returns to the river and natural spawning; productivity of naturally spawning salmon and steelhead; post-release migration behavior of hatchery fish in the river; and survival of program-origin fish from smolt release to adult return to the river;
- Documentation of fish cultural techniques used for listed Chinook salmon and steelhead propagation to gauge whether the programs are meeting objectives and to identify the need for adjustment to adequately safeguard the listed fish, including: broodstock collection and handling procedures, fish and egg condition at time of spawning, fertilization procedures, incubation methods/densities, temperature unit records by developmental stage, egg shocking methods, fungus treatment methods for eggs; start feeding methods, rearing/pond loading densities, feeding schedules and rates; fish release locations and methods; and fish mortality levels by life stage;
- Sampling and monitoring of fish health for all species under propagation consistent with co-manager Fish Health Policy procedures; and,
- Monitoring of hatchery- and natural-origin adult fish contributions to any in-river fisheries harvest that occur to remove remaining Chambers Creek hatchery-lineage adult steelhead, and after the harvest moratorium has lapsed in 2017.

The effects of these actions will be evaluated in this opinion.

1.3.7. Adaptive Management Activities

Incorporating approaches described in the MAMP for Chinook salmon and steelhead that relate to supportive breeding actions (EMG 2012) and following scientific guidance provided in the ERFRP (Ward et al 2008), the strategies described in the five HGMPs are intended to be adaptive, based on observed population viability parameter responses for Elwha River salmon and steelhead populations. The MAMP serves as the general monitoring and adaptive management action guidance framework for listed fish species and habitat recovery activities in the Elwha River watershed. As such, the HGMPs would implement select components of the MAMP that directly bear on supportive breeding. Although the HGMPs do not adopt the MAMP outright (WDFW 2012; LEKT 2012a), they adopt features of the MAMP that generally apply the approach specified in the MAMP, as it pertains to hatchery-related actions and effects.

In addition to recommending actions, the MAMP also serves as guidance or a framework, presenting strategies that address uncertainty, and incorporating recent methods and management responses. As such, while it is not part of the proposed action, the MAMP's scientific guidance helps inform NMFS' analysis of the recovery of Elwha River salmon and steelhead while minimizing the risks to these species from dam removal and stock preservation efforts (EMG 2012). It was therefore taken into consideration when evaluating the best available science and data, and informs NMFS determination of the proposed action.

The adaptive management process recommended by the MAMP would rely on performance indicators and triggers tied to hatchery performance and effects monitoring to guide associated management actions. The Chinook salmon and steelhead population viability trigger values described for the four restoration phases were developed to test the basic assumptions of the restoration program. In general, if certain hatchery rearing and release strategies prove to be unsuccessful in meeting population viability triggers in the MAMP, they may be discontinued at any time in favor of options that are more likely to produce healthy, self-sustaining populations. Specific options would include, for example, discontinuation of the release of yearling Chinook salmon into Morse Creek before the 12 year operational span has expired, when abundance triggers for fish escaping to spawn in the Elwha River for the preservation phase were met, and when the risk of catastrophic loss of the Elwha Chinook salmon population during and immediately after the dam removal phases had passed (Ward et al. 2008).

The MAMP population viability trigger levels are the key components that are carried forward in the HGMPs to guide the need to adjust supportive breeding actions affecting listed Chinook salmon and steelhead. Adaptive management responses in HGMP actions would be based on achievement of MAMP triggers. For example, when triggers marking the end of the recolonization phase for Chinook salmon are achieved, as estimated through monitoring and evaluation results, the Elwha Channel Hatchery program would be revised to reduce the proportion of hatchery Chinook salmon spawning naturally. The reduction could be accomplished through decreases in the number of Chinook salmon released through the program. Decisions regarding when and how the hatchery program would change would generally be consistent with the decision-making framework in the MAMP.

General application of the adaptive management approach referenced in the HGMPs, and using the MAMP as a general framework, will be assumed in the following evaluation of the effects of the proposed programs on listed fish during the preservation and recolonization phases of restoration. As mentioned previously in the sections describing the proposed Chinook salmon and steelhead supportive breeding actions, for the purposes of this opinion, the population viability status triggers developed by the EMG (EMG 2012) for Chinook salmon (Table 3) and steelhead (Table 4) are assumed by NMFS to be the best available science for identifying the status of the Elwha River Chinook salmon and steelhead populations propagated through the WDFW and LEKT program within these two proposed phases of operation.

1.4. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area for the analysis of the effects of the proposed activities is the Elwha River watershed where the salmon and steelhead hatchery programs are located. For the purposes of this consultation, the action area is defined as the Elwha River and its tributaries, extending from the upper river above the upper-most dam (Glines Canyon Dam at RM 13.4; see Figure 1), downstream to the mouth, including the Elwha River estuary. The action area encompasses the Elwha Channel and Lower Elwha Fish hatchery facility sites, the Elwha River watershed where fish produced by the programs would be released as juveniles and return as adults, and the estuary through which migrating hatchery-origin fish would pass as they enter the river as adults or exit the river as newly released juveniles.

ESA-listed salmonids in the watershed are the Elwha population of the threatened Puget Sound Chinook salmon ESU, and the Elwha River population of the threatened Puget Sound steelhead DPS. The southern DPS of eulachon, listed as threatened under the ESA, is also present in the lower portion of the action area, downstream of the site of Elwha Dam at RM 4.9. The Elwha River watershed and adjacent marine area have been designated as critical habitat for Puget Sound Chinook salmon, as has the portion of the river downstream of the Elwha Dam site for eulachon. Critical habitat has not yet been designated for the Puget Sound steelhead DPS. ESA listed Puget Sound/Washington Coastal DPS bull trout (*Salvelinus confluentus*) are also present in the Elwha River watershed. Listed bull trout are administered under the ESA by the U.S. Fish and Wildlife Service.

The Southern Resident population of killer whales (SRKW), listed as endangered under the ESA, transits marine waters near the action area. Three ESA-listed species of rockfish – boccacio, yellow-eye rockfish, and canary rockfish – may also be found in marine waters adjacent to the action area. Areas outside of the Elwha River watershed, where juvenile and adult salmon and steelhead produced by the proposed hatchery programs may co-occur with these listed species, and with listed salmon and steelhead from other areas, will not be included in the action area considered in this opinion for the following reasons.

The proposed hatchery programs would lead to unsubstantial changes in the total number of anadromous salmonids encountered by listed SRKWs and groundfish in Puget Sound and Pacific Coastal marine waters outside of the Elwha River. For example, the total numbers of juvenile Chinook salmon that would be released through the Elwha Channel Hatchery program are 2.5 million subyearlings and 400,000 yearlings. This annual production would be 6% of the 46.1 million hatchery-origin Chinook salmon released in Puget Sound each year. Further, the number of juvenile hatchery fish that survive to reach the ocean would be less than the number produced and released from the hatchery ponds. Exposure to natural conditions, including predation by piscivorous fish, bird, and mammal species, leads to high levels of mortality to juvenile hatchery-origin fish immediately upon their release into the natural environment. Although no studies are available for freshwater hatchery fish survival in the Elwha River, Seiler et al. (2004) and Volkhardt et al. (2006a) estimated that 37% to 80% of hatchery-origin spring, summer and fall sub-yearling Chinook salmon released upstream of juvenile out-migrant traps at RM 17 on the Skagit River survived the downstream journey to migrate past the traps. Freshwater survival for chum salmon fry was estimated to be 73.7% for fry released into a Puget Sound stream approximately 1.5 miles upstream from saltwater entry and 48.2% for fry released at 6 miles upstream (Fresh et al. 1980). Juvenile out-migrant trapping studies directed at post release survival for Green River hatchery fish estimated that 10.6% of Chinook salmon yearlings, and

13% to 70% of yearling steelhead released from upstream hatcheries each year survived to reach a trapping operation at river mile 33 (Seiler et al. 2004). Considering that Elwha River hatchery-origin fish would commingle with many other hatchery and wild juvenile salmonid populations besides those from Puget Sound (e.g., Fraser River; Columbia River; Washington Coast) in marine waters frequented by SRKWs and listed groundfish, the advent of hatchery fish released through the proposed Elwha River watershed would have inconsequential effects on those listed species.

The number of adult fish produced by the proposed hatchery actions would also represent an unsubstantial proportion of the total abundance of each species present in Puget Sound and in Pacific Coastal marine areas. For example, for the primary species produced through the proposed hatchery actions, the Elwha Channel Hatchery Chinook salmon program has led to an average annual return to Puget Sound of 2,104 adults in recent years (2000-2009) (estimated total adult return to the Elwha River from WDFW Run Reconstruction, January 8, 2010). The 2000-2009 average total run size for the species in Puget Sound is 247,917 fish, and the estimated total annual abundance of Chinook salmon from all regions in Washington State and British Columbia in Pacific Ocean coastal waters averages approximately 1,000,000 fish (L. LaVoy, NMFS, pers. comm., January 6, 2012). For these reasons, NMFS does not believe it is possible to meaningfully measure, detect, or evaluate the specific effects of Elwha River watershed hatchery juvenile and adult salmonid production on listed species in Puget Sound and the Pacific Ocean, due to the low magnitude of, and low likelihood for, effects in those locations. Therefore, the action area does not include Puget Sound.

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

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

2.1. Introduction to the Biological Opinion

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

"To jeopardize the continued existence of a listed species" means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02).

This biological opinion does not rely on the regulatory definition of 'destruction or adverse modification' of critical habitat at 50 C.F.R. 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[2]

We will use the following approach to determine whether the proposed actions described in Section 1.3 are likely to jeopardize listed species or destroy or adversely modify critical habitat:

- *Identify the range-wide status of the species and critical habitat likely to be adversely affected by the proposed action*. This section describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of the listed species' component populations in a "viable salmonid populations" paper (VSP; McElhany et al. 2000). The VSP approach considers the abundance, productivity, spatial structure, and diversity of each population as part of the overall review of a species' status. For listed salmon and steelhead, the VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" (50 CFR 402.02). In describing the range-wide status of listed species, we rely on viability assessments and criteria in technical recovery team documents and recovery plans, where available, that describe how VSP criteria are applied to specific populations, major population groups, and species. We determine the range-wide status of designated critical habitat by examining the condition of its physical or biological features (also called "primary constituent elements" or PCEs in some designations), which were identified when the critical habitat was designated. Species and critical habitat status are discussed in Section 2.2.

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

- *Analyze the effects of the proposed actions*. In this step, NMFS considers how the proposed action would affect the species' reproduction, numbers, and distribution or, in the case of salmon and steelhead, their VSP characteristics. Specifically for consultations on hatchery programs, NMFS looks at the proposed programs in the context of how hatchery actions might generally affect listed species. This includes the dual considerations of the species' likelihood of survival and recovery. NMFS also evaluates the proposed action's effects on critical habitat features. The effects of the action are described in Section 2.4 of this opinion.

[2] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

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

- *Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.* In this step, NMFS adds the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to assess whether the action could reasonably be expected to: (1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2). Integration and synthesis occurs in Section 2.6 of this opinion.

- *Reach jeopardy and adverse modification conclusions*. Conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 2.7. These conclusions flow from the logic and rationale presented in the Integration and Synthesis section (2.7).

- *If necessary, define a reasonable and prudent alternative to the proposed action.* If, in completing the last step in the analysis, NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a reasonable and prudent alternative (RPA) to the action in Section 2.8. The RPA must not be likely to jeopardize the continued existence of ESA-listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

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

This Opinion examines the status of each species that would be affected by the proposed action. The status is the level of risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value. Documents describing the listing status, critical habitat, and salmon and steelhead life histories are summarized in Table 8.

Table 8. Federal Register notices for final rules that list threatened species, designate critical habitats, or apply protective regulations to listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Puget Sound Chinook salmon *Oncorhynchus tshawytscha*	70 FR 37160, June 28, 2005	70 FR 52630, September 2, 2005	65 FR 42422, July 10, 2000; 70 FR 37160, June 28, 2005
Puget Sound steelhead *Oncorhynchus mykiss*	72 FR 26722, May 11, 2007	Not yet designated	73 FR 55451, September 25, 2008.
Eulachon *Thaleichthys pacificus*	75 FR 13012, March 18, 2010	76 FR 65324, October 20, 2011	75 FR 13012, March 18, 2010

"Species" Definition: In order to describe a species' status, it is first necessary to define what "species" means in this context. Traditionally, one thinks of the ESA listing process as pertaining to entire taxonomic species of animals or plants. While this is generally true, the ESA also recognizes that there are times when the listing unit must necessarily be a subset of the species as a whole. In these instances, the ESA allows a "distinct population segment" (DPS) of a species to be listed as threatened or endangered. Puget Sound steelhead constitute a DPS of the taxonomic species *Oncorhynchus mykiss*, and Puget Sound Chinook salmon constitute ESUs of the taxonomic species *Oncorhynchus tshawytscha*, and as such are considered "species" under the ESA.

NMFS reviews the range-wide status of the listed ESUs or DPSs affected by the proposed action using criteria that describe a "viable salmonid population" (VSP) (McElhany et al. 2000). A viable population has levels of abundance, productivity, spatial structure, and genetic diversity that enhance its capacity to adapt to various environmental conditions and allow it to become self-sustaining in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout the entire life cycle, characteristics that are influenced in turn by habitat and other environmental conditions.

Range-wide biological requirements of salmon and steelhead vary depending on the life history stage present and the natural range of variation present within the system (Groot and Margolis 1991; NRC 1996; Spence et al., 1996). For this action area, the biological requirements for Chinook salmon, steelhead and eulachon are the habitat characteristics that support successful spawning, rearing, and migration. These include water and passage conditions that allow access to and from spawning areas (migration), appropriate spawning substrate, cold clean water for egg, and alevin or larvae survival, shallow water margins for juvenile fish avoidance of predators, sufficient prey base for juvenile growth, presence of riparian vegetation, floodplain connectivity for refugia from high flows, and appropriate volumes and flows of water for rearing. The VSP parameters are influenced by how well these biological requirements are met within the geographic range of the species.

For listed Puget Sound salmonid populations, the ESUs and DPSs have been divided into populations (Ruckelshaus et al. 2006; PSSTRT 2012). The risk of extinction of each population is evaluated, taking into account population-specific measures of abundance, productivity, spatial structure, and diversity. Populations are grouped into ecologically and geographically similar strata (referred to as biogeographical regions (Chinook salmon) or Major Population Groups

(MPGs) (steelhead)), which are evaluated on the basis of population status. The individual populations, with their biogeographical regions or MPGs, are evaluated to assess ESU or DPS viability status using ESU or DPS-level viability criteria developed by the Puget Sound Chinook salmon and Steelhead TRTs (Ruckelshaus et al 2002; Hard et al., pending).

In assessing range-wide status, NMFS starts with the information used in its most status review (Ford et al. 2011) and also considers more recent data, where applicable, that are relevant to the species' range-wide status. Recent information from recovery plans is also relevant and is used to supplement the overall review of the species' status. This step of the analysis tells NMFS how well the species is doing over its entire range in terms of trends in abundance and productivity, spatial distribution, and diversity. It also identifies threats to the species viability.

The status review starts with a description of the general life history characteristics and the population structure of the ESU, including the biogeographical regions or MPGs where they occur. We review available information on VSP criteria including abundance, productivity and trends (information on trends supplements the assessment of abundance and productivity parameters), and spatial structure and diversity. Available estimates of extinction risk are used to characterize the viability of the populations and ESU or DPS and limiting factors and threats are identified. We also review available information on the status of the biogeographical regions or MPGs and individual populations within the action area. This section concludes by commenting on the status of critical habitat.

Recovery plans are an important source of information that describe, among other things, the status of the species and its component populations, limiting factors, recovery goals and actions that are recommended to address limiting factors. Recovery plans are not regulatory documents. Consistency of a proposed action with a recovery plan therefore does not by itself provide the basis for a no jeopardy determination. However, recovery plans do provide an "all-H" perspective that is important when assessing the effects of an action.

Information from the Shared Strategy for Puget Sound Plan (Ruckelshaus et al. 2005) – the recovery plan for Puget Sound Chinook salmon - is discussed where it applies in various sections of this opinion. Completed in 2005, the SSPS plan was developed by a nonprofit organization that coordinates recovery planning for Puget Sound salmonids. Assembly of the plan was assisted by representatives of Federal, state, tribal, and local governments, business, the agriculture and forestry industries, conservation and environmental groups, and local watershed planning groups. The reasons for Chinook salmon decline are generally analyzed in the Plan in terms of limiting factors and threats. Limiting factors are defined as the biological conditions limiting population status (e.g. elevated water temperature). Threats are defined as those human activities or naturally induced actions that cause the limiting factors (e.g. loss of shade from riparian vegetation). The Plan examines the general threats and limiting factors for Chinook salmon recovery, with extensive detail provided for populations in each Puget Sound watershed. The major limiting factors are described in relation to the biological needs of the species and in categories of habitat, harvest, hatchery management, and additional factors such as climate change, fluctuating ocean conditions, and marine mammal interactions. After identifying threats to recovery, the Plan describes specific recovery strategies and measures that will be used to guide actions at the watershed level to mitigate the threats. The Shared Strategy approach relied on the work of 14 individual watershed planning areas to set goals for the individual Chinook salmon populations (e.g., for Elwha Chinook, Volume II of SSPS 2007). A recovery plan for the Puget Sound steelhead DPS has not yet been completed.

Also bearing on the status of the species, and the treatment of Chinook salmon in this opinion, is application of NMFS's Population Recovery Approach (PRA) to assign the standing of Chinook salmon populations for recovery of the ESU (NMFS 2010c). The PRA is a systematic framework that guides NMFS's assessment of the relative impact of proposed actions (harvest, hatchery, habitat, and hydropower) to individual populations and, subsequently, the survival and recovery of the ESU. NMFS assesses the risk to survival and recovery of the ESU using the PRA. The PRA evaluates each of the 22 identified populations in the Puget Sound Chinook salmon ESU through the same comprehensive, systematic, and transparent process. The PRA overlays watershed and stock information from the SSPS recovery plan on the population structure of the ESU (Ruckelshaus et al. 2005; 2006), to develop a tool that can be used to prioritize resources and, through ESA consultation processes, provide common guidance in the agency's assessment of the relative impact on the recovery of the ESU of proposed actions (harvest, hatchery, habitat and hydropower) affecting individual populations or watersheds across the ESU. Based on the combined information, populations are assigned to one of three tiers. The assigned tier indicates the relative role of each of the 22 populations comprising the ESU to the viability of the ESU and its recovery. Not all populations have an equal role in the survival and recovery of the ESU. Tier 1 populations are most important for preservation, restoration, and ESU recovery. Tier 2 populations play a less important role in recovery of the ESU and Tier 3 populations play the least important role. When NMFS analyzes a proposed action, it evaluates impacts at the individual population scale for their effects on the viability of the ESU. Impacts on Tier 1 populations would be more likely to affect the viability of the ESU as a whole than similar impacts on Tier 2 or 3 populations, because of the relatively greater importance of Tier 1 populations to overall ESU viability. NMFS will adjust this tiered prioritization approach in response to changes in the status of populations and the condition of the habitat they use and in response to new information.

Under the PRA, the Elwha Chinook salmon population is considered to be a "Tier 1" population. This status will inform NMFS's assessment of the effects of the proposed hatchery actions on overall ESU viability and conservation value under the ESA. In general, negative effects on the Elwha population would be more likely to reduce the chances of survival and recovery of the Chinook salmon ESU than negative effects on populations with less important roles (Tier 2 and 3 populations).

2.2.1. Puget Sound Chinook salmon

General information regarding Chinook salmon biology can be found in Myers et al. (1998). NMFS completed an ESA status review of Chinook salmon from Washington, Idaho, Oregon, and California in 1998 (Myers et al. 1998). Through the review, fifteen distinct ESUs of Chinook salmon (Oncorhynchus tshawytscha) were identified in the western United States region. For the purposes of conservation under the ESA, an ESU is a distinct population segment that is substantially isolated, reproductively, from other conspecific population units and represents an important component in the evolutionary legacy of the species (Waples 1991). After assessing information concerning Chinook salmon abundance, distribution, population trends, risks, and protection efforts, NMFS determined that the Puget Sound Chinook salmon ESU is at risk of becoming endangered in the foreseeable future. The ESU was subsequently listed as "threatened" under the ESA on March 24, 1999 (64 FR 14308). A 2011 status review update (NMFS 2011a) resulted in a continued threatened listing status designation for Puget Sound Chinook salmon (76 FR 50448, August 15, 2011). The Puget Sound Chinook salmon ESU includes all naturally spawned Chinook salmon populations residing below impassable natural barriers (e.g., long-standing, natural waterfalls) in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula, inclusive. NMFS also included Chinook salmon produced by 26 hatchery programs within the region as part of the listed Puget Sound Chinook salmon ESU (70 FR 37160). NMFS designated critical habitat for Puget Sound Chinook salmon on September 2, 2005 (70 FR 52630).

Overall abundance of Chinook salmon in this ESU has declined substantially from historical levels and many populations are small enough that genetic and demographic risks are high. Due to their current small size or fragmentary spatial distribution, ESU populations may be more prone to loss of key portions of their genetic make-up, or be unable to, for example, find mates in sufficient numbers. At the time of listing, both long- and short-term trends in abundance were predominantly downward, and several populations were exhibiting severe short-term declines. The updated assessment of the status of the ESU indicates that all Puget Sound Chinook salmon populations are well below minimum planning ranges for recovery escapement levels, and that reevaluation of the threatened status for the ESU is not warranted (NMFS 2011b). Most of the populations are also consistently below spawner/recruit levels needed for recovery.

In an earlier NMFS status review, Good et al (2005) found that earlier-returning Chinook salmon populations and life history types throughout the Puget Sound ESU have become particularly diminished. These life histories have exhibited widespread declines throughout the ESU and some runs are considered extirpated. These losses represent a troubling reduction in the life history diversity and potentially the populations of this ESU (Myers et al. 1998; 64 FR 14308, March 24, 1999; Ruckelshaus et al. 2006). The Puget Sound Technical Recovery Team (PSTRT) has discussed the importance of these losses to the historical population structure of the ESU relative to the extant populations (Ruckelshaus et al. 2006). The PSTRT provided guidelines for recovery of the Puget Sound Chinook salmon ESU (Ruckelshaus et al. 2002) that were accepted by NMFS as delisting criteria for the ESU (NMFS 2006b). The delisting guidelines address losses in ESU abundance and productivity and include recommendations for protection and recovery of diversity and spatial structure characteristics at both the population and ESU levels. Other concerns regarding the status of Puget Sound Chinook salmon noted by NMFS are the concentration of the majority of natural production in just two basins, high levels of hatchery production in many areas of the ESU, and widespread loss of estuary and lower floodplain habitat diversity and, likely, associated life history types (Good et al. 2005). Populations in this ESU have not experienced the sharp increases in the late 1990's seen in many other West Coast Chinook salmon ESUs. After adjusting for changes in harvest rates, however, trends in productivity are less favorable. Most populations are relatively small, and recent abundance within the ESU is only a small fraction of estimated historical run size.

The Puget Sound Chinook salmon ESU has suffered substantial losses in characteristics important to long-term persistence. The losses include declines in abundance, productivity, diversity, and spatial structure of the 22 independent historical populations present within the geographical boundaries of ESU identified by NMFS (Myers et al. 1998; Figure 2). Evidence suggests that the Puget Sound Chinook salmon ESU has lost 15 spawning aggregations that were either demographically independent historical populations or major components of the life history diversity of the remaining independent historical populations identified (Ruckelshaus et al. 2006). Although rigorous identification of extinct independent populations is not possible, information on the above loss of diversity is important for protection and recovery of the ESU. Nine of the 15 putatively extinct spawning populations were early-run type Chinook salmon, including the spring-run race in the Elwha River (Ruckelshaus et al. 2006). The disproportionate loss of early-run life history diversity represents a particularly damaging loss of the evolutionary legacy of the historical ESU.

As part of its responsibility as an independent scientific body convened by NMFS to develop technical delisting criteria and guidance for salmon delisting in Puget Sound, the PSTRT identified 22 demographically independent populations of Chinook salmon in the Puget Sound ESU, including the Elwha population (Ruckelshaus et al. 2006). The natural-origin Chinook salmon affected by the proposed hatchery actions evaluated in this opinion are part of the Elwha population delineated by the PSTRT. Included in the listed Elwha Chinook salmon population are all natural-origin fish produced by naturally spawning Chinook salmon in the mainstem Elwha River, its side channel areas, and its tributaries that have been accessible to the species downstream of Elwha Dam. Hatchery fall-run Chinook salmon originating from WDFW's Elwha Channel Hatchery program are included with the natural-origin Chinook salmon as part of the listed Elwha population (70 FR 37160, June 28, 2005). In accepting the Shared Strategy Plan (Ruckelshaus et al. 2005) as the approved recovery plan for the Puget Sound Chinook salmon ESU, NMFS identified the Elwha Chinook salmon population as a key population needing to be restored to a low extinction risk status for recovery of the Strait of Juan de Fuca biogeographical unit and and for the ESU as a whole to be possible (NMFS 2006b). Also, consistent with this NMFS finding and as mentioned previously, the population is designated as a Tier 1 population for ESU recovery under the NMFS PRA (NMFS 2010c).

The current Elwha Chinook salmon population is a summer/fall-run race spawning in several dozen areas in the mainstem Elwha River from RM 0.3 to RM 4.9, and in side-channel areas in the lower river, primarily Hunt's Road side channel. The Puget Sound TRT concluded that Chinook salmon currently spawning in Morse Creek, an independent tributary to the Strait of Juan de Fuca eastward of the Elwha River,are also part of the Elwha Chinook salmon population (Ruckelshaus et al. 2006). The spring-timed run of Chinook salmon that existed historically in the Elwha River watershed likely became extinct when the river was blocked to upstream fish migration by placement of the Elwha Dam in 1911 (Brannon and Hershberger 1984, Wunderlich et al. 1993). Completion of the Elwha Dam blocked access of Elwha Chinook salmon to 95 percent of the historical range for Chinook salmon. The response of the species, in terms of reduced abundance, productivity, and spatial distribution was immediate (Haring 1999; Crain et al., 2004; DOI 1996). Two of the main tributaries historically used by Elwha Chinook salmon but blocked to the species' access are Little River and Indian River, both located upstream of Elwha Dam. Historical upstream limits of salmon in the mainstem Elwha are not well documented and likely varied by species (Pess et al, 2008). The Elwha Report (DOI et al., 1994) concludes that RM 34 was the historical upper extent of summer/fall Chinook salmon migration,

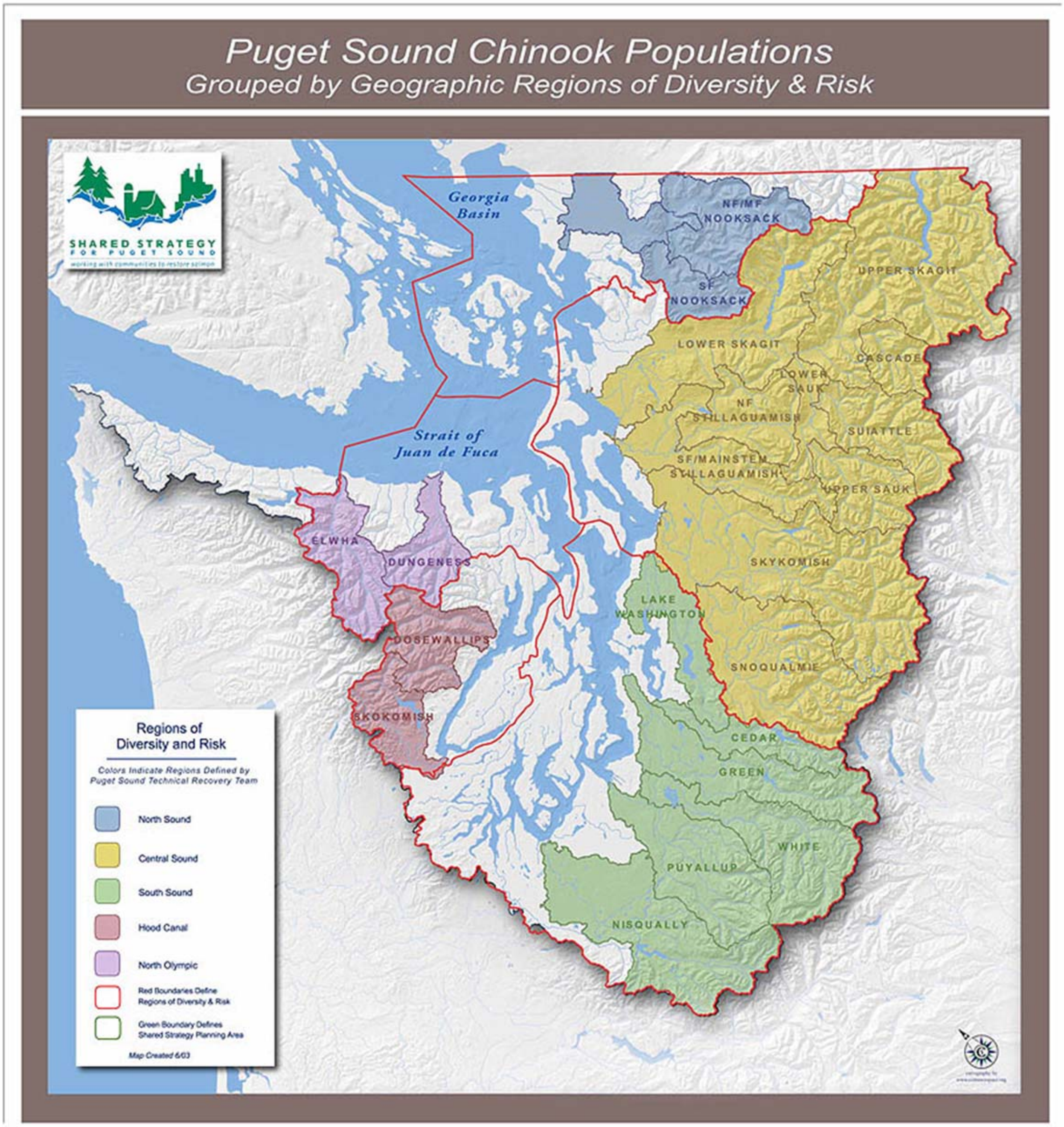

Figure 2. Location of Chinook salmon populations and biogeographical regions within the Puget Sound Action Area. Source: Ruckelshaus et al. 2005).

with spawning by spring Chinook salmon extending further upstream to the mouth of Delabarre Creek at about RM 40. As noted above, prior to 2011, adult Chinook salmon could only ascend the mainstem Elwha River to river mile 4.9, where further access was blocked by the Elwha Dam. Anadromous fish access to areas upstream of RM 4.9 and extending to RM 8.5 (including Little River and Indian River) was restored beginning in 2011 with removal of Elwha Dam.

Complete removal of Glines Canyon Dam in 2013 or 2014 will allow upstream migration of Chinook salmon into historically used areas above RM 13.4.

Migrating adult fish enter the river beginning in early June and extending through early October (Figure 3). Spawning in the Elwha River begins in late August and peaks in late September to early October (WDF et al. 1993). Data collected from gaffed adults, fish volunteering to Elwha Channel Hatchery, and spawning ground surveys (WDFW database, 1987-98) indicate that Elwha River Chinook salmon range in size from 45 cm to126 cm (fl) (WDFW 2012). Although the Elwha River spring-run Chinook salmon is believed to be extirpated, and the extant population is considered to be a summer/fall race, tribal set net fishery catch data used to derive Chinook salmon adult entry estimates indicate that a bi-model return portrayed by a very small number of early-entering fish, and a much larger number of later-entering fish, may still persist (Crain et al. 2004).

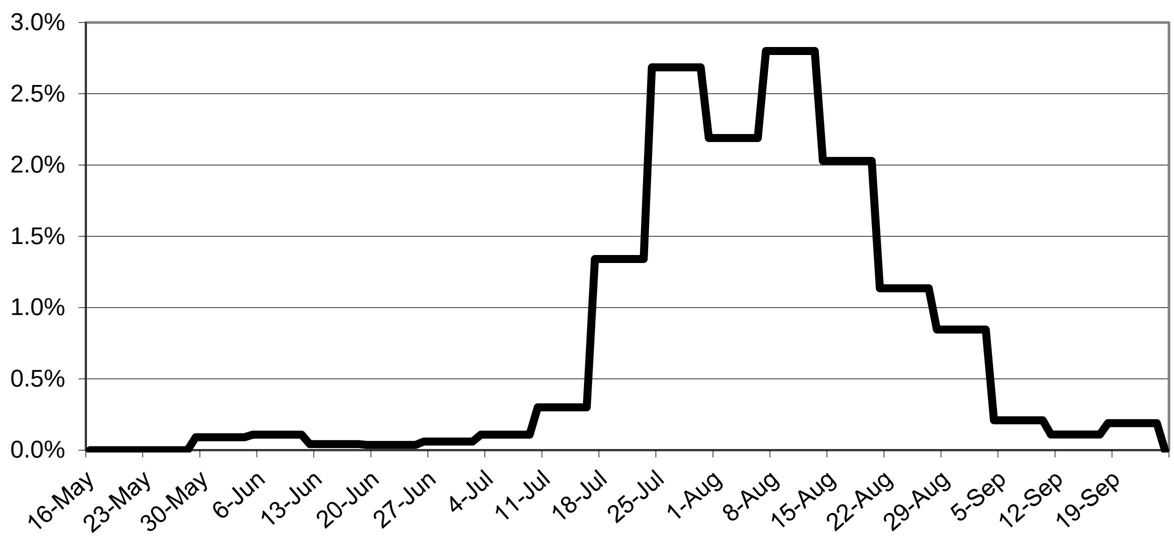

Figure 3. Daily entry pattern (percent of total run per day) for upstream migrating Elwha River adult Chinook salmon derived from Lower Elwha Klallam Tribe set net fishery Chinook salmon harvest data for 1988 – 1993. Source: N. Lampsakis, Point No Point Treaty Council, and Crain et al. (2004).

The extant Chinook salmon population is an ocean- type race, exhibiting a downstream juvenile out-migration strategy (life history type and timing) similar to other ocean type, fall-run Chinook salmon populations in Puget Sound (Figure 4). After emerging from the gravel, the majority of juveniles emigrate into downstream areas immediately in February or March as fry. To reach smolt size, the fry and later emigrating juvenile Chinook salmon spend two to six months in lower river and side channel habitats downstream of RM 4.9 before emigrating out of the system seaward. The juvenile Chinook salmon population in the river emigrates seaward predominantly during their first winter and spring as sub-yearling fish. A small proportion of the current naturally produced Chinook salmon population may continue to rear in lower river habitat and emigrate the following spring as yearlings. All life history types are likely to spend some time in the remaining Elwha River estuary, and perhaps in suitable, brackish water nearshore areas

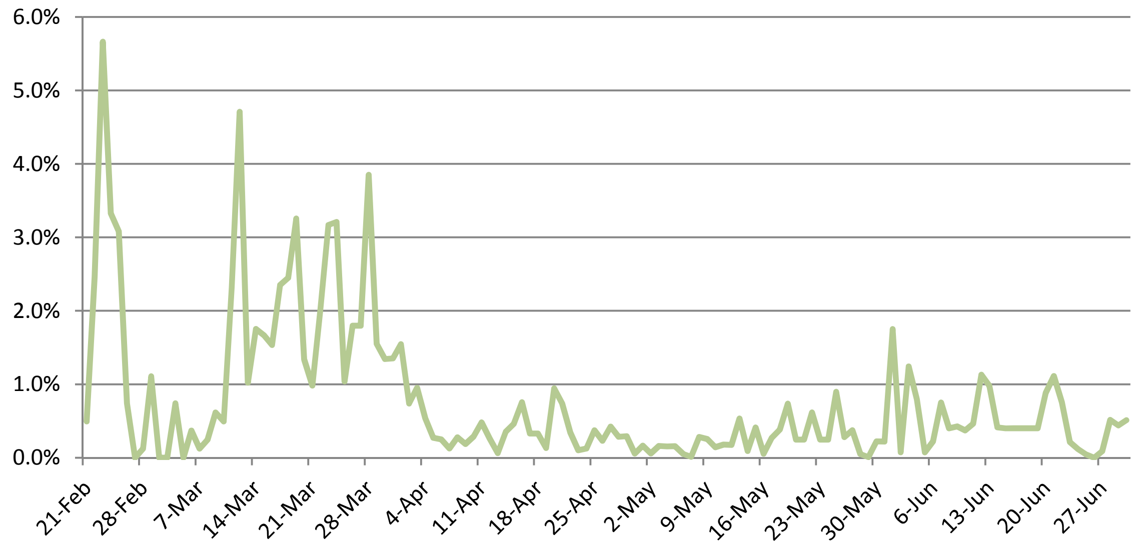

Figure 4. Estimated downstream emigration timing for Elwha Chinook salmon presented as percent of total migrating population per day. Curve derived from average daily catch per unit effort data for 0-age Chinook salmon collected at the Lower Elwha Klallam Tribe screw trap operated at RM 0.6 on the mainstem Elwha River. Source: 2005-2007 average CPUE estimates from M. McHenry, LEKT (2010).

(Levings et al. 1986) to grow to a sufficient size allowing their adaptation to marine waters (70 mm fl – Healey 1991).

Little is known regarding the behavior of Elwha Chinook salmon after juvenile fish enter the Strait of Juan de Fuca. Genetic analyses of Chinook salmon captured through beach seining in nearshore marine waters west of the mouth of the Elwha River in 2007 indicate that a high percentage (43%) of the total number of sub-yearling Chinook salmon encountered in the area during the early summer months originated from either the Elwha or Dungeness rivers (A. Shaffer, WDFW, 2008 unpublished data). Distribution analysis of the juvenile fish collected in this study suggested that Chinook salmon occurrence in the Strait of Juan de Fuca west of the Elwha River was strongly associated with specific habitat types within the Pysht River mouth area, Crescent Bay, and Freshwater Bay (Figure 1). The annual duration of their residence as rearing and migrating juveniles in these areas is unknown. Similar to other ocean-type Chinook salmon populations in Puget Sound, Elwha Chinook salmon likely migrate northward along the coast of Vancouver Island to rear in areas adjacent to the coasts of British Columbia and Southeast Alaska. Coded wire tag (CWT) recovery data for Pacific Ocean fisheries indicate that Puget Sound stocks exhibit a similarity in marine distribution (Myers et al. 1999). Tagged fish have been primarily captured in Canadian coastal and Puget Sound waters. Elwha Chinook salmon CWT recoveries in Alaska and Puget Sound fisheries show an ocean distribution for the stock to be intermediate between Puget Sound stocks and farther north-migrating Washington coast stocks. Beamish et al. (2003) summarize the results of studies of the early ocean period of salmon life history conducted in the coastal areas off Canada's West Coast where rearing and migrating juvenile and sub-adult Elwha Chinook salmon may be found. They reported that ocean and climate conditions are important contributors to the total marine mortality of Chinook salmon in coastal waters, and to the stock and recruitment relationship for the species.

After rearing in Puget Sound and the Pacific Ocean, maturing adult Elwha Chinook salmon return to the Elwha River primarily at age-4 and age-5, comprising an average of 59 and 29 percent, respectively, of the adult fish escaping to the Elwha River each year (data for 1992-1994 from WDF et al 1993; and WDFW 1995 cited in Myers et al. 1998). On average, approximately 13 percent of the adult Chinook salmon returning to the river are age-3 fish.

Abundance

Abundance of Elwha Chinook salmon is substantially reduced from historical levels, and abundance of the remaining population is further threatened in the short term by excessive sediment and turbidity levels resulting from dam removal (Ward et al. 2008). Total Chinook salmon abundance over the last 35 years, natural-origin and hatchery origin fish combined, has ranged from 929 to 9,083 fish, and averaged 2,575 fish (Figure 5). The total abundance of Chinook salmon escaping to the Elwha River in the most recent 12 years (1999-2010) averaged 1,808 fish, and ranged between 1,146 and 3,443 fish (Table 9). The total (hatchery plus natural-origin fish) escapement goal of 2,900 fish has been met in only one year over this period. Of the total recent year return, an average of 821 fish (45 percent) have escaped to spawn naturally. An average of 1,140 fish have been removed for use as broodstock in the hatchery supplementation program at Elwha Channel Hatchery.

Under the ERFRP, the abundance target for the population at 10 years is 2,000 fish spawning naturally (regardless of origin) and 6,900 natural-origin fish spawning naturally at 25 years (Ward et al. 2008). For the purposes of this opinion, population viability triggers established by the EMG (EMG 2012) will be assumed as the primary targets for guiding Elwha Chinook salmon restoration actions, including supportive breeding. The total adult return abundance triggers for Chinook salmon for the preservation phase of restoration are 1,700 hatchery-origin fish and 1,028 natural-origin fish, of which 707 would originate from ocean-type emigrants and 321 would originate from stream-type emigrants (Table 3 - EMG 2012). The triggers delineating recolonization phase abundance goals are 1,700 returning hatchery-origin adults and 4,847 natural-origin adults, of which 3,333 are of ocean-type smolt origin and 1,314 are of stream-type origin (EMG 2012). For ESA recovery planning purposes under the SSPS recovery plan, the equilibrium abundance target is 17,000 fish, and the planning range for abundance is 17,000 to 30,000 spawners (Ruckleshaus et al. 2005; SSPS 2007).

In the 1980s and early 1990s, a substantial proportion of the total number of adult Chinook salmon escaping into the river each year died prior to spawning under conditions where river flows were low and water temperatures were high. Over the period from 1986 through 1996, pre-spawning mortality averaged 25.2% per year and ranged from 0.5% to 68.3% percent of the population, due largely to parasitic infestations by *Dermocystidium salmonis*, promoted by

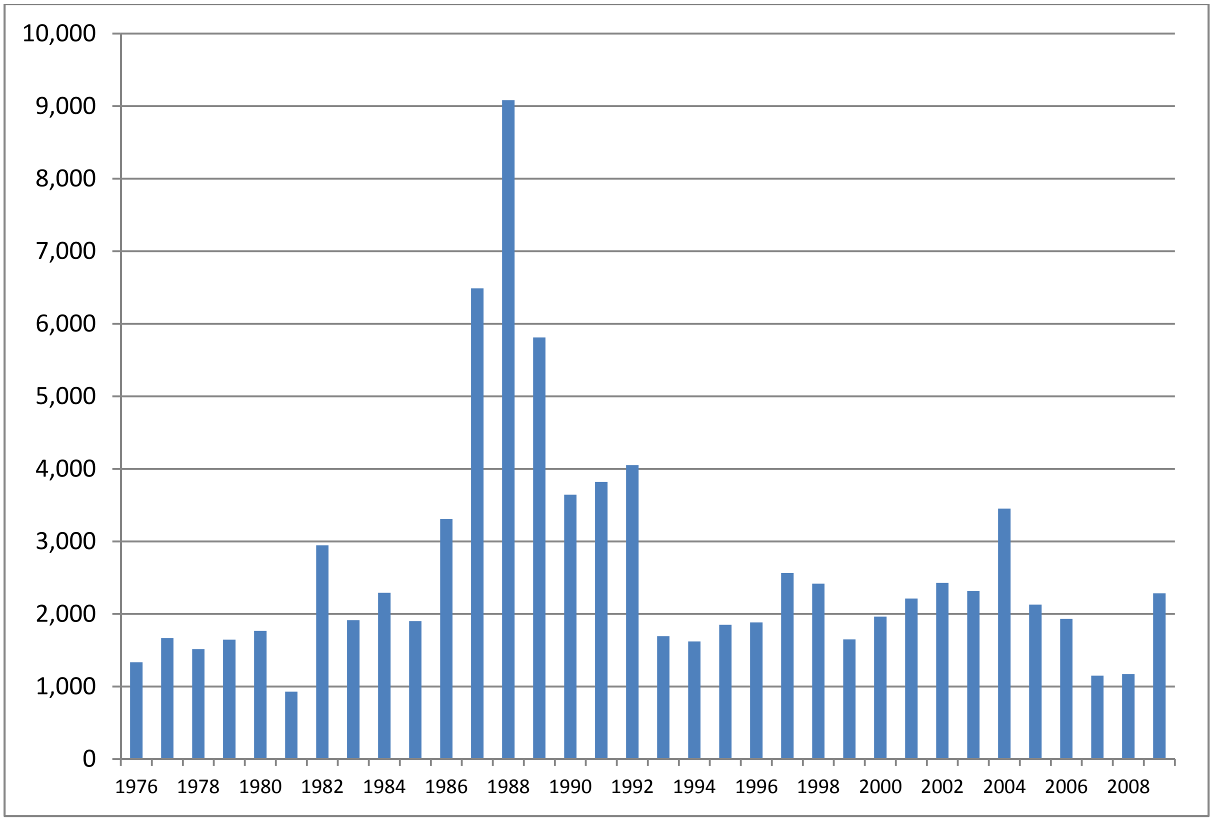

Figure 5. Total escapement, hatchery and natural-origin fish combined, of Chinook salmon to the Elwha River – 1976 through 2010. Source: WDFW Run Reconstruction - January 8, 2010, and WDFW 2012.

periodically high water temperatures. In 1992, about two-thirds (68%) of the adult Chinook salmon that returned to the Elwha River died prior to spawning after succumbing to D. *salmonis*. Risks of high pre-spawning mortality associated with this parasite continue, particularly during extreme low flow years and when water temperatures exceed 60 degrees F.

The ability to differentiate hatchery- from natural-origin Chinook salmon in natural spawning areas in the lower Elwha River has been limited by the lack, until recently, of a consistent, differentiating mark or tag on hatchery-origin fish. The only brood years when hatchery-origin Chinook salmon were adipose-fin clipped/coded-wire tagged to allow for their distinction from natural-origin fish were 1992 through 1994. These coded wire tagged groups were applied for the purpose of assessing fisheries harvest effects and distribution, and not hatchery versus natural-origin escapement levels for adults returning to the river. Analyses of otolith data collected from adult Chinook salmon that spawned in Hunt's Road side-channel, an area thought to have provided an important natural production area for the species after the side-channel became watered and accessible for spawning by the species in the mid-1990s, showed that the natural spawning contribution of returning natural-origin fish was unsubstantial relative to hatchery-origin fish. First generation hatchery-origin fish comprised 76% (2008 return year) and 96% (2009 return year) of the total number of fish sampled from the area (Stenberg et al. 2010), suggesting that Chinook salmon spawner use and production in the side-channel was being

Table 9. Elwha Chinook salmon escapement estimates, 1999 – 2010 (WDFW 2012).

Year	Total Escapement to River	Broodstock Removals	Pre-spawning Mortality	Natural Spawning Escapement, hatchery and natural-origin fish combined
1999	1,625	699	23	903
2000	1,913	1,136	62	715
2001	2,246	1,553	38	655
2002	2,416	1,513	40	863
2003	2,305	1,182	78	1,045
2004	3,443	1,329	39	2,075
2005	2,238	1,396	7	835
2006	1,931	1,227	11	693
2007	1,146	757	9	380
2008	1,153	667	16	470
2009	2,181	1,514	16	651
2010	1,278	709	5	564
Average	1,808	1,140	29	821

Source: WDFW 2012.

sustained through the continual contribution by hatchery-origin spawners, rather than through substantial natural-origin fish adult returns and production.

From a more recent analysis of adult fish recovery data, WDFW field staff collected mark, coded-wire tag and otolith information from returning adult Chinook salmon in 2007 through 2010 from fish returning to the Elwha Channel Hatchery trap and from adults collected/sampled from the run-at-large in the Elwha River. For this period, WDFW estimates that approximately 95% of the total Chinook salmon adult returns to the river in 2008, 2009, and 2010 originated from Elwha River basin hatchery programs and just 4% were of natural-origin (WDFW 2012). The estimated total numbers of natural-origin three and four-year old Chinook salmon (the predominant ages at adult return for Puget Sound fall-run populations) escaping to the Elwha River in 2008 and 2009 were 63 and 62 fish, respectively (WDFW 2012). Data from WDFW and PNPTT (2010) indicate the abundance status of the natural-origin component of the Elwha Chinook salmon population for the brood years studied was the poorest of any of the populations composing the listed Puget Sound Chinook salmon ESU, with the exception of South Fork Nooksack in 2009 (Table 6 in NMFS 2011b).

It is likely that for many decades, the majority of the Chinook salmon observed on the spawning grounds, averaging 1,800 fish in recent years, have been hatchery-origin fish. This is a sensible conclusion, as estimates of the proportion of natural-origin fish spawning in the watershed prior to differential marking of hatchery-origin fish have been speculative based on observations of total spawner use of areas thought to allow natural fish segregation and sustainability (i.e. Hunt's Road side-channel). Mark recovery analysis now enabled by mass marking of hatchery-origin fish indicates otherwise. Long term confinement of naturally spawning fish to under 10% of their historical habitat and less than 5 miles of mainstem habitat downstream of Elwha Dam, and the static, degraded condition of that habitat (e.g., impaired sediment recruitment and routing caused by the dams) combined with the lack of an adequate estuary (ocean-type Chinook salmon are highly dependent on a functioning estuary – Levings et al. 1986), diminish the likelihood that natural-origin Chinook salmon production and returns have been substantial relative to hatchery-origin returns. All recent year juvenile hatchery Chinook salmon release groups in the basin have been mass marked with thermally induced otolith marks and/or blank coded wire tags without adipose fin clips to minimize mark-selective fisheries impacts on returning adult fish, while allowing continued estimation of hatchery versus natural-origin fish contributions to total returns and natural spawning abundances as the dams are removed, and as the river and estuary recover.

There are currently no fisheries impacting the abundance of the Elwha Chinook salmon population through direct harvest. Fisheries for Chinook salmon have been curtailed since the 1980s in the Elwha River, and adjacent marine area fisheries have been restricted as specific measures to minimize impacts on the Elwha Chinook salmon population. A five year moratorium on fisheries for all species in the Elwha River, extending from 2012 through 2017 and encompassing the dam removal phase, will further limit harvest risks to Chinook salmon. Elwha Chinook salmon are harvested incidentally in U.S. and Canadian mixed stock marine area fisheries targeting more abundant salmon stocks.

The harvest distribution of Elwha Chinook salmon has been described based on analysis of coded-wire tagged fingerling Chinook salmon released from Elwha Channel Hatchery (WDFW 2011). For brood years 1992 and 1993, 64 percent of the total harvest mortality for Elwha Chinook salmon occurred in British Columbia and Alaska. Washington troll and Puget Sound net fisheries accounted for 4 percent of the total fishery mortality. U.S. marine area (ocean and Puget Sound) recreational fisheries accounted for 32 percent of total mortality over the two brood years.

Other estimates of harvest levels for Elwha Chinook salmon from post-season Fisheries Resource Assessment Model (FRAM) simulations indicate that the total exploitation rate for Elwha River Chinook salmon decreased in the late 1990's, averaging 54% prior to 1998, and dropping to 21% from 1998 to 2001 (PSTT and WDFW 2010). From 2002 through 2006, rates climbed slightly, averaging 35% over that period. This increase is attributed to northern (Canada and Alaska) fisheries, as exploitation rates in southern U.S. fisheries remained static and at relatively low levels of less than 5% (Table 10). These post-season FRAM estimates represent aggregates of the two Strait of Juan de Fuca populations (Elwha and Dungeness), but are believed to correctly represent the exploitation rate trend for the Elwha population (PSIT and WDFW 2010).

Table 10. Fishery-related adult equivalent exploitation rates of Elwha River Chinook salmon for management years 2000-2006, estimated by post-season FRAM validation runs.

Year	Total	Alaska/BC	Southern US
2000	18%	16%	2%
2001	19%	16%	3%
2002	31%	26%	5%
2003	36%	30%	6%
2004	34%	30%	4%
2005	39%	36%	3%
2006	34%	31%	3%

Marine area fisheries in Washington waters impacting the Elwha Chinook salmon population, including those under jurisdiction of the Pacific Fisheries Management Council, have been managed since the 1990s so as not to exceed a southern U.S. incidental fishery adult equivalent exploitation rate of 10.0% on Elwha Chinook salmon when the escapement goal is not projected to be met (PSTT and WDFW 2010). Harvest at this level assists recovery by helping to maintain spawner escapements to perpetuate natural spawning, and by providing sufficient broodstock for the Elwha Channel Hatchery program. This harvest impact limit represents a marked decline in harvest levels on the stock in the 1980s and early 1990s in southern U.S. fisheries. The exploitation rate on the U.S. Strait of Juan de Fuca management unit aggregate that includes Elwha Chinook salmon averaged 24% for return years 1983 – 1996. Since 1997, actual exploitation rates averaged less than 4%. Under the current harvest management approach (2010 through the present), whenever spawning escapement for the Elwha stock is projected to be below 1,000 spawners (a composite of 500 natural and 500 hatchery spawners), southern U.S. fisheries will be managed to further reduce incidental adult equivalent mortality on Elwha Chinook salmon to less than 6.0% (PSTT and WDFW 2010).

Release of stored sediments behind Elwha and Glines Canyon dams will threaten the abundance of the naturally spawning Chinook salmon population over the period of dam removal (2011-2014), and for an unknown period until lower river habitat conditions stabilize. Inhospitable sediment and water quality conditions during, and for at least several years following, the dam removal period will adversely affect survival of fish spawning in remaining lower river and side channel habitat. Threatened with loss are two or three of the four predominantly 4-year-old fish brood cycles of Chinook salmon reproducing naturally in remaining habitat downstream of Elwha Dam. Loss of these brood lines would substantially reduce the abundance of natural-origin Elwha Chinook salmon from already critically depressed levels. As a measure to conserve genetic resources and reduce risks to Elwha Chinook salmon abundance as a result of dam removal and as a means to preserve the population, NMFS required that adult Chinook salmon be removed from the river at levels sufficient to fully meet hatchery broodstock needs for WDFW's Elwha Channel Hatchery programs (NMFS 2006a; NMFS 2012a).

In the most recent status review for the Puget Sound Chinook salmon ESU, NMFS found that for all populations, including the Elwha, abundances are well below escapement abundance planning ranges identified as required for recovery to low extinction risk in the SSPS Plan (NMFS 2011a). Natural-origin Chinook salmon escapements have remained fairly constant during the time period of review (1985-2009). NMFS concluded in its updated review that new information on

ESU abundance, productivity, spatial structure and diversity since the Good et al. (2005) review does not indicate a change in the biological risk category since the time of the last BRT status review (NMFS 2011b). The ESU has made little progress toward meeting recovery criteria and current trends in abundance were negative for many populations (NMFS 2011a). The Elwha population has maintained a flat total abundance in recent years (Figure 5). The recent year (2000-2010) average escapement of 821 naturally spawning fish (natural- and hatchery-origin combined) remains below the 10-year interim recovery goal of 2,000 fish (41%) and well below the recovery abundance planning target of 17,000 fish (4.8%). Short (1995-2009) and longer term (1986-2009) abundance trend estimates for the Elwha Chinook salmon population (based on over-estimates of likely, actual natural-origin fish contribution levels) remain under 1.0 (0.97 and 0.93 respectively - NMFS 2011b). Naturally spawning fish abundance is further threatened over the short term by dam removal effects, but natural-origin abundance should increase over the longer term towards recovery targets as the population recolonizes the upper river watershed post-dam removal. Pess et al. (2008) hypothesize that in general, salmonids will respond to dam removal by establishing persistent, self-sustaining salmonid populations in watershed areas above Elwha Dam within one to five generations (two to twenty years) following dam removal. But, as noted in Ward et al. (2008), substantial uncertainty exists regarding the expectation that fish will naturally recolonize the watershed within a “reasonable” time frame. The extant populations that use the river below Elwha Dam, including Chinook salmon, are in chronically low abundance and, further, have a high likelihood for adverse effects from dam removal and resultant release of stored sediment. Conditions that will be present in the river below the dams during and immediately following dam removal may result in mortality rates approaching 100% for any naturally rearing fish, including Chinook salmon, virtually eliminating the local natural-origin brood source of species for recolonization (Ward et al. 2008).

Spatial Structure

Spatial structure of the Elwha Chinook salmon population has been adversely affected by dam construction and operation in the watershed, and spatial structure will be further impaired as a result of dam removal activities. The construction of the Elwha Dam in 1911 blocked access to about 90 percent of their historical range. Access to 100 percent of the areas that supported spring-run Chinook salmon was blocked. Natural salmon production habitat remaining below the Elwha Dam is of generally poor quality, with only a small area of relatively high quality habitat remaining in about two dozen main-stem and side-channel sites (e.g., Hunt’s Road side-channel). This remnant area provides a small, but confined amount of suitable spawning habitat for Chinook salmon returning to the Elwha River, but recent analysis of the origin of escaping fish indicates that contribution to total annual adult returns of the species is unsubstantial (mark recovery analysis data for brood years 2008-2010 in WDFW 2012).

The release of stored sediments behind Elwha and Glines Canyon Dams will threaten the spatial structure of the naturally spawning Chinook salmon population remaining in the lower river. Changes in the condition of existing lower river Chinook salmon habitat will result from unstable channel features such as stream bed aggradation and movement due to an increase in sediment supply for the first five years during and after dam removal, which can result in detrimental effects on salmon habitat capacity and survival (Beechie et al. 1996). Inhospitable sediment and water quality conditions during and for an unknown number of years following the dam removal period will adversely affect use of lower river and side channel habitat available for Chinook salmon spawning, incubation, rearing and migration – the only habitat features remaining for the Elwha Chinook salmon population prior to restoration of upstream anadromous fish access. The spatial structure of the Elwha population is threatened over the short term.

NMFS concluded in its updated ESU status review that new information on spatial structure and other viability parameters since the last species review does not indicate a change in the ESU's "moderate" biological risk category. The ESU remains relatively well distributed over 22 populations in 5 biogeographic areas across the Puget Sound (NMFS 2011a), and the Elwha population remains extant in its remaining, confined lower river habitat. The spatial structure of the Elwha population should improve substantially after anadromous fish connectivity between the lower and upper Elwha River watershed is restored, and as the population recolonizes the newly available upper river habitat in 2012 and beyond. Under the ERFRP (Ward et al. 2008), the interim spatial structure target for Chinook salmon restoration is re-establishment of habitat use up to RM 42.9 in the Elwha River mainstem. Under the four-tiered restoration approach, the spatial structure triggers for the population are some adults spawning naturally above Elwha Dam site during the preservation phase, and adults spawning naturally above Elwha Dam at 33% of the estimated intrinsic potential population level during the recolonization phase (Table 3; EMG 2012).

Diversity

Genetic diversity of the Elwha Chinook salmon has been adversely affected by anthropogenic activities, primarily dam placement and operation, and is no doubt substantially reduced relative to historical levels. Currently, only a fraction of the original diversity of the species remains (Pess et al. 2008). The spring-run Chinook salmon race, an important genetic component of the Elwha return (as expressed by early river entry, large adult body size, and spawning typically high in the watershed) have been largely extirpated from the Elwha River (Brannon and Hershberger 1984; Wunderlich et al. 1993). Loss of access to upriver habitat coupled with possible interbreeding with summer/fall Chinook salmon in the lower river, since they were confined to the lower river because of dam construction, are the primary causes of the spring Chinook salmon decline. Diversity of the extant summer/fall run of Chinook salmon population has been reduced as a result of their confinement to 10% of their historically available habitat, and degradation and loss of habitat within the lower river area where the population has been confined.. The current population of summer/fall stock was found to be genetically intermediate between Puget Sound and Washington coastal populations and considered to be a transitional population between the Puget Sound and Washington Coastal Chinook salmon ESUs (Myers et al. 1999). Some allozyme markers suggest a genetic affinity of the Elwha River population with the Washington coastal stocks, while others indicate an affinity with Puget Sound stocks.

Release of stored sediments behind Elwha and Glines Canyon dams will threaten the remaining diversity of the naturally spawning Chinook salmon population. Inhospitable sediment and water quality conditions for an unknown number of years following the dam removal period will adversely affect the survival of fish spawning in remaining lower river and side channel habitat available for Chinook salmon (Ward et al. 2008). At risk are two or three of the four brood cycles of Chinook salmon that remain. Loss of these brood lines would substantially reduce the diversity of Elwha Chinook salmon. As a measure to conserve genetic resources and reduce the risk level for diversity,NMFS required that adult Chinook salmon be removed from the river at levels sufficient to fully meet hatchery broodstock needs for WDFW's Elwha Channel Hatchery program as one means to preserve the population (NMFS 2006a; 2012a).

NMFS concluded in its updated ESU status review that new information on diversity and other viability parameters since the last review did not indicate a change in the ESU's "moderate" biological risk category. The ESU remains relatively well distributed over 22 populations in 5 biogeographic areas across the Puget Sound (NMFS 2011a), and the Elwha population remains extant in its remaining, confined lower river habitat. The remaining diversity of the Elwha population should be retained and improve substantially after anadromous fish access is restored to the upper Elwha River watershed, and as the population recolonizes the newly available habitat in 2012 and beyond. The target interim goal for restoration of Chinook salmon population diversity in the ERFRP is the recovery of natural-origin spring and summer/fall races (Ward et al. 2008). The diversity trigger for the preservation and recolonization phases of restoration is "no change" from the current genetic diversity of the Elwha Chinook salmon population (Table 3 - EMG 2012).

Productivity

Productivity of the Elwha natural-origin Chinook salmon population is suppressed, with the species recruiting below replacement levels. Ford et al. (2011) provided estimates of short-term median population growth rates (lambda) assuming hatchery-origin fish productivity was "0" and assuming that hatchery-origin fish productivity was equal to natural-origin fish "1". They reported short (1995-2009) and long (1986-2009) term trends of 0.94 and 0.90, respectively, assuming hatchery-origin fish productivity of 0, and 0.78 and 0.76 assuming hatchery-origin fish productivity of 1.0. Elwha Chinook salmon are not replacing themselves under any of these estimates.

WDFW monitoring of natural-origin Chinook salmon productivity in the lower river portion of the Elwha River, where natural production has been confined, began with assessment of the progeny to adult escapement rate for the 2004 brood year (WDFW 2012). Inclusion of recent adult return data has also allowed assessment of productivity for the 2005 brood year. For the two brood years, juvenile to adult survival rates to escapement were low – 0.044% for the 2004 brood year and 0.096% for the 2005 brood year. By comparison, the ESU-wide progeny to adult escapement rate for naturally spawning Chinook salmon in Puget Sound is 0.39%, assuming a recent year (1999-2005) average total juvenile out-migrant estimate of 9.42 million fish and an average natural-origin adult escapement for the same period of 36,533 fish (NMFS SMD unpublished data, 2012). The survival estimates for Elwha Chinook salmon and total Puget Sound Chinook salmon are based on assessments of adult spawning escapement abundances and do not include fish taken in fisheries. Assuming overall fisheries exploitation rates are comparable for Elwha and other Puget Sound Chinook salmon populations, the substantially lower survival estimates for Elwha Chinook salmon indicate that natural-origin spawner productivity is substantially impaired relative to the average Puget Sound population.

Like Elwha River natural-origin Chinook salmon, survival to adult escapement estimates for hatchery-origin Elwha River Chinook salmon are low when compared with Puget Sound-wide expectations for subyearling hatchery releases. Elwha Channel Hatchery subyearling Chinook salmon survival rates to adult spawner for return years 1999-2008 ranged from 0.02% to 0.14%

and averaged 0.07% (R. Cooper, WDFW, unpublished data, cited in PSTT and WDFW 2010). The overall survival rate to fisheries and escapement for Puget Sound hatchery sub-yearlings, based on rates experienced for regional production programs, is 0.5% (Fuss and Ashbrook 1995). Assuming an average fisheries exploitation rate of 38% for a sub-yearling origin release group lacking a terminal area fishery impact (e.g., Hoko Fall Fingerling Chinook salmon – 1999-2005 average from CTC 2008), the comparable adult escapement survival "goal" metric for Puget Sound hatchery subyearlings would be 0.34% - a rate nearly 5 times greater than the recent year average survival to escapement rate for Elwha hatchery subyearlings.

Under the ERFRP (Ward et al. 2008), the interim natural-origin Chinook salmon productivity target is > 1.0 recruits per spawner, and 4.6 recruits per spawner at maximum sustainable yield conditions for the population. The productivity triggers delineating the preservation and recolonization phases of restoration are identified in Table 3 (EMG 2012). For the preservation phase, the triggers are 200 juveniles produced per female; a hatchery+natural fish R/S (spawner to spawner) rate of >1.0 ; and a pre-fishing hatchery+natural fish R/S rate of >1.56. The same figures apply for the recolonization phase, but the R/S triggers address natural-origin fish productivity only. Considering current growth rate trends and natural- and hatchery-origin fish survival rates to escapement, current productivity for the Elwha Chinook salmon population is well below these targets and triggers. Achievement of the target productivity levels is dependent on the condition and pace of recovery of lower river habitat and Chinook salmon productivity in that area, and the pace of natural fish recolonization and restoration of productivity in newly accessible up-river freshwater environment.

Summary of the Status of the Elwha Population of Puget Sound Chinook salmon

Puget Sound Chinook salmon continue to be at risk of becoming endangered in the near future and remain threatened under the ESA (76 FR 50448, August 15, 2011). As one of only two populations in the Strait of Juan de Fuca biogeographical region, the Elwha Chinook salmon population has been recognized as a key (Tier 1) population needing to be restored to a low extinction risk status for recovery and delisting of the ESU (NMFS 2006b; NMFS PRA 2010). Overall abundance of Elwha Chinook salmon has declined substantially from historical levels, and the total population is small enough that genetic and demographic risks are high. Spawner abundance in the Elwha River has remained relatively stable over the past ten years, although the vast majority of abundance is due to hatchery-origin fish spawning. Considering the preponderance of hatchery-origin adult returns relative to natural-origin fish, remaining diversity for the population resides primarily in the hatchery population – a condition likely decades in duration. The population has been confined to less than 5 miles of spawning area for the long term, relative to the 90 miles of river habitat historically accessible, and disruption of population spatial structure has been severe. Adverse effects on productivity associated with confinement of spawning to a degraded lower river area with no viable estuary are evidenced by poor progeny to adult survival rates for listed natural- and hatchery-origin fish. Over the short term, the Elwha Chinook salmon population and the lower river habitat sustaining the population are further threatened by the effects of dam removal. The abundance, spatial structure, diversity, and productivity of the remaining natural-origin population are expected to become further impaired relative to current conditions through adverse effects associated with the release of stored sediments behind the dams as they are removed. Over the longer term, viability parameter status for the population should improve substantially as lower river and estuary habitat recovers, and as naturally spawning Chinook salmon recolonize newly accessible upper Elwha River areas, and become the predominant component of total spawner abundance and productivity.

2.2.2. Puget Sound Steelhead

General information regarding steelhead biology can be found in Busby et al. (1996), Hard et al. (2005), and PSTRT (2012). Steelhead are the anadromous version of freshwater rainbow trout. The typical life history involves two to three years of juvenile freshwater rearing before migration downstream as smolts into marine waters. Once the smolts emigrate, they move rapidly through Puget Sound into the North Pacific Ocean where they reside for several years before returning to spawn in their natal streams. Unlike other members of the Oncorhynchus genus with an anadromous life history, some adult steelhead do not die after spawning and can undergo multiple spawning cycles (Wydoski and Whitney 1979).

A NMFS Biological Review Team (BRT) completed an ESA status review of the Puget Sound steelhead DPS in 2007, concluding that the DPS was at risk of becoming endangered in the foreseeable future (Hard et al. 2007). NMFS concluded that, at present, protective efforts in Puget Sound do not substantially mitigate the factors threatening the DPS's future viability, nor do they ameliorate the BRT's assessment of extinction risk. For the purposes of the Act, NMFS and the U.S. Fish and Wildlife Service adopted a joint policy for recognizing DPSs under the ESA (DPS Policy - 61 FR 4722, February 7, 1996). NMFS applied the DPS policy in delineating species of West Coast O. mykiss for consideration under the ESA. After assessing information concerning steelhead abundance, distribution, population trends, risks, and protection efforts, NMFS originally listed the Puget Sound Steelhead DPS as "threatened" under the ESA on May 11, 2007 (72 FR 26722).

The listed Puget Sound Steelhead DPS includes all naturally spawned anadromous O. mykiss (steelhead) populations from streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive). Resident O. mykiss occur within the range of Puget Sound steelhead but are not part of the DPS due to marked differences in physical, physiological, ecological, and behavioral characteristics (71 FR 15666; March 29, 2006). In its final listing determination (72 FR 26722, May 11, 2007), NMFS included two hatchery populations that were derived from native steelhead (Green River winter-run and Hamma Hamma winter-run) as part of the listed DPS, providing protection for them with other wild populations under the ESA. Five additional steelhead hatchery populations, derived from native stocks and propagated in several new supplementation programs in the region, were recommended for inclusion as part of the listed DPS through NMFS's 2011 updated status review: Elwha native winter-run, White River winter-run, Dewatto winter-run, South Fork Skokomish winter-run, and Duckabush winter-run (NMFS 2011b).

The extant natural-origin late winter-run steelhead population in the Elwha River is part of the Puget Sound steelhead DPS, listed as threatened. This late-returning winter-run population is delineated as a distinct independent population by NMFS (PSSTRT 2012; Figure 6). Hatchery-origin steelhead derived from the natural-origin late-returning population

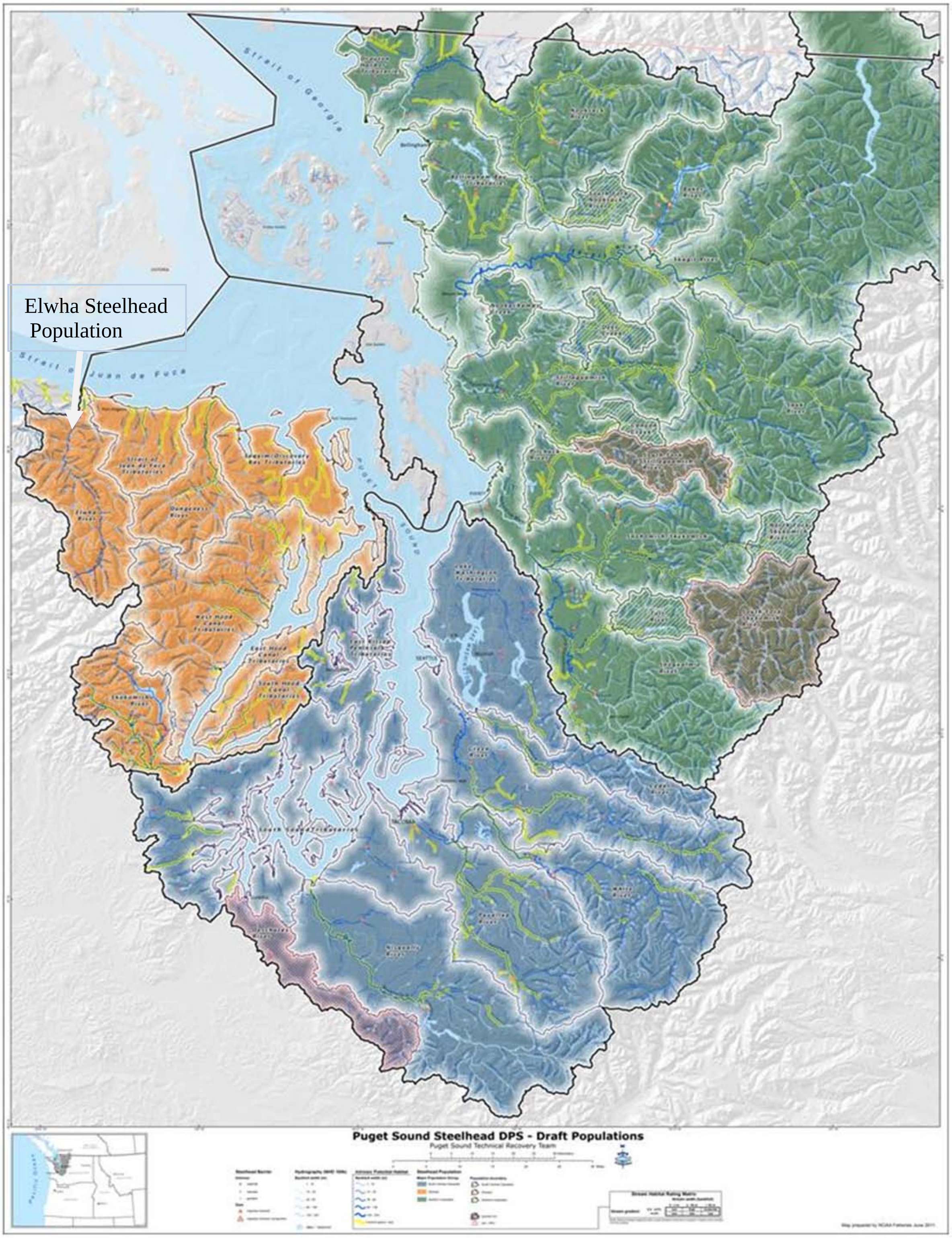

Figure 6. Location of distinct independent populations and major population groups that are part of the Puget Sound steelhead Distinct Population Segment. Source: Puget Sound Steelhead Technical Recovery Team (2011 draft).

and propagated through the Lower Elwha Hatchery program (LEKT 2012a) are included as part of the listed DPS and protected under ESA provisions (76 FR 50448, August 15, 2011). Transplanted, Chambers Creek Hatchery lineage (early-timed) steelhead produced through the tribal hatchery program from 1976 through 2011 (LEKT 2012b) are not part of the listed DPS (73 FR 55451, September 25, 2008). Early-timed hatchery steelhead in the Elwha River therefore cannot contribute to recovery of the species, and are not proposed for use in restoration of a natural-origin, self-sustaining steelhead population in the watershed (LEKT 2012a; LEKT 2012b; Ward et al. 2008).

Little is known about the historical status of the native steelhead population(s) in the Elwha River. Since anadromous fish access to habitat upstream of RM 4.9 was blocked by construction of the Elwha Dam in 1911, it is certain that the viability of the species was adversely affected to a substantial degree. Historically, there is some evidence indicating a summer-run steelhead population may have been present in the Elwha River, but if present, it is likely that the run was extirpated or became residualized when the Elwha River dams were constructed (Puget Sound Steelhead TRT, 2012). There is little information other than anecdotal accounts of historical harvest levels of steelhead in the river to indicate the pre-dam status of steelhead population(s) in the basin (PSSTRT 2012), but the Elwha River was identified in historical documents as supporting both Native American and commercial steelhead fisheries (PSSTRT 2012, citing Rathbun 1900).

Natural steelhead spawning currently occurs throughout the mainstem and tributaries below Elwha Dam. Genetic analyses indicate that “early-returning” winter-run steelhead are largely derived from transplanted Chambers Creek Hatchery stock originating from a now-terminated harvest augmentation program. Later-returning (native stock) winter-run steelhead are different from the early-returning, hatchery-origin stock (Winans et al. 2008). Early-returning hatchery steelhead spawning ends prior to mid-March (PSSTRT 2012). Later-timed, natural-origin Elwha River winter-run steelhead are believed to enter freshwater and spawn from February through June (McMillan et al. 2010).

Little is known about other freshwater life history stages for the native population of winter-run steelhead in the lower Elwha River. The typical life history for Puget Sound winter-run steelhead involves spending one to three years rearing in freshwater before migrating downstream into marine waters. Morrill (1994 - cited in PSSTRT 2012) reported that Elwha winter-run steelhead emigrated seaward primarily as age-2 smolts (77%) with age-3 (15%) and age-1 (8%). McMillan et al. (2010 – citing Brenkman et al. 2008) reported that although native, natural-origin steelhead are depleted in the lower Elwha River, the upper watershed above the dams supports an abundance of resident rainbow trout. These resident rainbow trout are thought to be an admixture of native and introduced O. mykiss populations (Winans et al 2008). A proportion of the fish produced in the upper river produce seaward-migrating smolts (Brenkman et al. 2008). Juvenile steelhead out-migrant trapping data for the Elwha River are lacking but it is likely, based on known emigration timing for other regional stocks, that natural-origin steelhead juveniles emigrate seaward from the river in April and May as smolts, predominantly during their second spring in freshwater. Elwha River adult winter-run steelhead spend 2 years (51%) or 3 years (46%) rearing in the ocean before returning to spawn for the first time (Morrill 1994, cited in PSSTRT, 2012). One trait of the species is that some adult steelhead do not die after spawning and can undergo multiple spawning cycles (Wydoski and Whitney 1979). Repeat spawners typically average 3.6% (±3.4%) in Puget Sound (WDFW unpublished data).

Abundance

Abundance of the late-returning, native, winter-run Elwha River steelhead population is believed to be substantially reduced from historical levels, and abundance of the remaining population is further threatened on the short term by excessive sediment and turbidity levels resulting from dam removal (NMFS 2006a; Ward et al. 2008). The historical population size for the native Elwha River steelhead population is unknown (Ward et al. 2008). However, using the parr production potential approach to estimate basin carrying capacity, Gibbons et al (1985) estimated that the Elwha River in a pristine state could produce 10,100 adult recruits. Using an intrinsic productivity model, PSSTRT (2012) later estimated that historical steelhead abundance in the Elwha River was 5,873 fish, assuming unrestricted anadromous fish access to presently blocked upper river areas.

From 1985 through 1997, WDFW estimated that spawning escapements for native Elwha River winter-run steelhead ranged from 47 to 834 fish, with an average return of 323 fish over the 12 year period (LEKT 2012a). Limited spawner escapement surveys conducted since 2002 have documented an average of 50–100 late returning steelhead redds per year. In 2005, 61 discrete redds were identified in the lower river (Ward et al. 2008). Estimated total steelhead abundance in recent years averaged 141 fish and ranged from 45 to 246 fish, based on redd counts for years for which data are available; redd counts are expanded by 2.62 adults/redd to develop an estimate of adults contributing (Table 11; LEKT 2012a). These escapement estimates are the best information available, but replicated spawning surveys to monitor escapements throughout the entire steelhead return period are often prevented by high flow and turbidity (LEKT 2012a).

Table 11. Estimated number of late-returning steelhead escaping to spawn in the Elwha River.

Run Year	Number of steelhead
2005	100
2006	123
2007	-
2008	-
2009	45
2010	193
2011	246

Source: LEKT 2012a.

The co-managers' draft harvest plan for Puget Sound steelhead set the critical escapement threshold for Elwha steelhead at 100 fish and the viable population threshold range at 500 to 750 fish (PSIT and WDFW 2010). These thresholds were developed to inform harvest management in the short term, but lack a technical basis in current or future potential productivity in the

Elwha River (LEKT 2012a). The Elwha River watershed also supports an abundance of resident *O. mykiss* rainbow trout above the dams (Brenkman et al. 2008). Resident *O. mykiss* are expected to contribute to recolonization of steelhead throughout the watershed (Brenkman et al. 2008), but the resident form of the species is not included as part of the listed Puget Sound steelhead DPS (72 FR 26722) and the focus of restoration is the anadromous component of the native *O. mykiss* population.

The interim abundance target identified in the ERFRP for the late-returning winter-run steelhead population at 10 years is 1,500 fish spawning naturally (regardless of origin) and 5,757 natural-origin fish spawning naturally at 25 years (Ward et al. 2008). The recent year (2005-06; 2009-2011) average escapement of 141 fish (all natural-origin) is 9.4% of the ERFRP 10-year interim recovery goal (Ward et al. 2008). For the purposes of this opinion, population viability triggers established by the EMG (EMG 2012) will be used to guide Elwha native steelhead restoration actions, including supportive breeding. The adult return abundance objective delineating the transition from the preservation to the recolonization phase is 500 natural-origin and 300 hatchery-origin adults (Table 4; EMG 2012). The adult return abundance trigger ending the recolonization phase and marking the beginning of the local adaptation phase is 969 natural-origin fish and 300 hatchery-origin fish.

Prior to 2005, there was no artificial propagation of the late-returning winter-run steelhead population. As part of an effort to preserve and restore the depleted natural-origin population, in winter/spring 2006 the LEKT initiated collection of eyed eggs and fry genetically identified as of native-origin from steelhead redds in the river to create a captively reared population. Four brood years have been represented as captive broodstock and maintained in the hatchery. The first progeny of captive broodstock adult steelhead reared through the tribal program were released into the Elwha River as two-year-old smolts in 2011. The first adult returns from these releases will begin in 2013, and for at least four years thereafter will contribute to the total abundance of the late-returning steelhead population. Survival rate data for Elwha hatchery-origin steelhead is unavailable due to uncertainty regarding escapement levels to natural spawning areas. Assuming a smolt-to-adult return survival rate of 0.75% (“goal” survival rate for the LEKT winter-run steelhead (LEKT 2012a)), the release of 175,000 smolts as proposed each year could result in the annual return of 1,313 adult native stock steelhead to the Elwha River.

There have been no directed fisheries since the late 1970s that would lead to the harvest and substantial reduction in river abundance of the late-returning steelhead population. In recognition of the depleted state of the natural population, tribal and recreational fisheries have long targeted only early-returning hatchery steelhead that enter the river prior to the majority of late-returning fish. A small portion of the late-returning native run was taken incidentally each year during tribal and recreational fisheries targeting early-returning (Chambers stock) hatchery-origin steelhead produced at Lower Elwha Fish Hatchery. LEKT steelhead catch monitoring data for 1982 – 1996 show that late-returning steelhead comprised approximately 6% of the total annual tribal fishery harvest. Annual harvests in tribal fisheries directed at early-returning Chambers Creek lineage steelhead ranged from 173 to 296 fish (2003-04 through 2007-08), so estimates are that 10 to 18 fish from the natural population may have been harvested annually by the LEKT in the Elwha River. This approach overestimates more recent year impacts on the late-returning steelhead population, because during the years examined, the tribal fishery extended into March. To minimize incidental harvest of late-returning steelhead, recent fisheries directed at hatchery-origin early-returning steelhead were terminated no later than February 28th (LEKT 2012a).

For now, hatchery-origin late-returning steelhead produced by this program are intended for population conservation and recovery purposes only. Adult returns from the supportive breeding program, beginning in 2013 and extending through the preservation phase, would therefore not be subject to any directed harvest. As steelhead population viability parameter monitoring indicates a transition to the recolonization phase of restoration, hatchery steelhead in excees of conservation and recovery needs will be harvested by the LEKT (LEKT 2012a). The LEKT has submitted separately to NMFS an “Elwha Steelhead Harvest Management Plan” describing objectives and guidelines relevant to managing harvest of steelhead in the Elwha River. Included in the plan is harvest of remaining, returning early-timed (Chambers Creek lineage) steelhead adults in management seasons 2012-13 and 2014-15. Effects on listed steelhead of this fishery were evaluated and approved under the ESA by NMFS (NMFS 2011b). Although hatchery-origin native steelhead will begin returning in 2013, fisheries in the Elwha River targeting this stock would only be considered beginning in 2017, following the end of the moratorium on in-river fishing (LEKT 2012a). The plan for harvesting hatchery steelhead that are surplus to conservation and recovery needs will set limits on harvest and on the incidental take of steelhead from the natural population. In a separate ESA consultation under the 4(d) Rule tribal resource management plan limit, NMFS is expected to determine whether steelhead harvests in the Elwha River would be implemented consistent with ESA conservation standards to avoid impeding the recovery of the native steelhead population. Effects of this harvest plan are not part of the proposed actions considered in this opinion.

The status of summer steelhead is unknown, but any population, if still extant, is suspected to be at a critically low abundance level (Ward et al. 2008), and possibly an artifact of Skamania hatchery-lineage steelhead strays to the river (PSSTRT 2012). Periodic high water temperatures during the summer in addition to frequent out breaks of Dermocystidium greatly reduce survival for adult fish in the lower river during this period. Thus, it is likely that the native summer steelhead population was extirpated following the construction of the Elwha River dams (PSSTRT 2012). Alternatively, remnant summer-run steelhead may have been residualized in tributaries to the Elwha River above the dams. The majority of the Puget Sound Steelhead TRT concluded that the summer-run component of Elwha River steelhead is no longer in existence.

Release of stored sediments behind Elwha and Glines Canyon dams will threaten the abundance of the naturally spawning steelhead over the period of dam removal (2011-2014), and for an unknown period afterwards until lower river habitat conditions stabilize. Inhospitable sediment and water quality conditions, for at least several years following dam removal, will reduce survival of fish spawning in remaining lower river and side channel habitat available for natural-origin steelhead production. The risk is that two to three of the four predominantly 4-year-old fish brood cycles of steelhead reproducing naturally in the remaining habitat downstream of Elwha Dam could be lost. Loss of these brood lines would substantially reduce the abundance of natural-origin Elwha River steelhead from already critically depressed levels. As a measure to reduce extinction risks during the dam removal period and as a means to preserve the population, NMFS required that unmarked adult steelhead encountered at basin weirs and traps be removed from the lower river for use as hatchery broodstock for LEKT's native winter-run steelhead supportive breeding effort, or be transported and released upstream to spawn naturally in unaffected habitat areas (NMFS 2012a).

In the most recent status review for the Puget Sound Steelhead DPS, NMFS found that since 1995, Puget Sound winter-run steelhead abundance has shown a widespread declining trend over much of the DPS (NMFS 2011b). The native Elwha steelhead population was among the most severely affected, with sharply declining population trends over both the long (1985-2009) and short (1995-2009) terms. NMFS concluded that new information on DPS abundance, productivity, spatial structure and diversity since the last steelhead status review by Hard et al (2007) does not indicate a change in the biological risk category of likely to become endangered in the foreseeable future (NMFS 2011b). Naturally spawning fish abundance is further threatened over the short term by dam removal effects, but natural-origin abundance should increase over the longer term towards recovery targets as the population recolonizes and adapts to the upper river watershed post-dam removal. Pess et al. (2008) hypothesize that in general salmonids will respond to dam removal by establishing persistent, self-sustaining salmonid populations in watershed areas above Elwha Dam within one to five salmon generations (two to twenty years) following dam removal. But, as noted in Ward et al. (2008), substantial uncertainty exists regarding the expectation that fish will naturally recolonize the watershed within a "reasonable" time frame. The extant populations that use the river below Elwha Dam, including steelhead, are in chronically low abundance and there is a high likelihood that abundance will be reduced further because of dam removal and the resultant release of stored sediment. Conditions that will be present in the river below the dams during and immediately following dam removal may result in mortality rates approaching 100% for any naturally rearing fish, virtually eliminating the natural-origin brood source of species for recolonization (Ward et al. 2008).

Spatial Structure

Spatial structure of the Elwha River steelhead population has been adversely affected by dam construction and operation in the watershed, and spatial structure will be further affected as a result of dam removal activities. The construction of the Elwha Dam in 1911 blocked access to 90 percent of their historical range, and steelhead have been confined for 100 years to the lowest 5 miles of the watershed (Figure 4). Further, 100% of summer steelhead historical range (upper reaches of the watershed) was eliminated. Suitable habitat in the lower river has been reduced because the construction of the Elwha dams truncated the alluvial transport of sediment, resulting in the coarsening of river bed, leading to the loss of spawning habitat below the dams (Pess et al. 2008). From 1939 to 2002, the lower Elwha River lost over 75% of the available spawning habitat for all salmonids because of dam-caused disrupted sediment transport processes. Between 1991 and 2002 the decline in spawning area was reversed, as the river shifted course into the Hunt's Road side- channel, exposing a relatively large area of newly created spawning habitat, and increasing available lower river habitat by 56% over 1991 levels (Pess et al. 2008). However, current steelhead habitat below Elwha Dam remains in generally poor quality, with only a small area of relatively high quality habitat available for natural steelhead production in about two dozen main-stem and side-channel areas, including Hunt's Road side-channel.

Release of stored sediments behind Elwha and Glines Canyon dams as they are removed will further threaten the spatial structure of the naturally spawning winter-run steelhead population. Degradation in the condition of existing lower river steelhead habitat will result from unstable channel features such as stream bed aggradation and movement. These changes will result from an increase in sediment supply for the first five years during and after dam removal, which can result in detrimental effects on habitat capacity and productivity (Beechie et al. 1996). Inhospitable sediment and water quality conditions during and following the dam removal period (2011-2014) will adversely affect use of lower river and side channel habitat available for steelhead spawning, incubation, rearing and migration – the only natural spawning and production habitat remaining for the Elwha River native steelhead population prior to restoration of upstream anadromous fish access. The spatial structure of the Elwha River steelhead population is threatened over the short term.

NMFS concluded in its updated ESU status review that new information on spatial structure and other viability parameters since the last review does not indicate a change in the ESU's "moderate" biological risk category. The Elwha River winter-run steelhead population remains extant in the lower river habitat where the population has been confined for 100 years at critically low annual abundance levels. The spatial structure of the Elwha population should improve substantially after anadromous fish connectivity between the lower and upper Elwha River watershed is restored, and as the population recolonizes the newly available upper river habitat in 2014 and beyond (Figure 7).

Under the ERFRP (Ward et al. 2008), the interim spatial structure target for steelhead restoration is re-establishment of habitat use up to RM 42.9 in the Elwha River mainstem, and in all accessible upper river tributaries. For the purposes of this opinion, population viability triggers established by the EMG (EMG 2012) will be used to guide Elwha native steelhead restoration actions, including supportive breeding. The Elwha River steelhead population spatial structure objective, delineating the transition from the preservation to the recolonization phase, is "some" steelhead adults spawning above Elwha Dam site at 9% of the intrinsic potential estimated for the species for the middle and upper river areas (Table 4; EMG 2012). The spatial structure objective, delineating the end of the recolonization phase, is steelhead adults spawning above Elwha Dam at 33.5% of the estimated intrinsic potential for the species.

Diversity

As a consequence of dam construction and resultant degradation of downstream habitat, diversity of Elwha River steelhead is substantially reduced from historical levels. Occurrence, distribution, and connectivity of *O. mykiss* life history forms have been severely affected, to the detriment of within and among population genetic diversity in the watershed. For example, loss of access to upper watershed areas caused by dam construction has led to decreased life-history diversity for the species (Beechie et al. 2006). Historically, most summer steelhead used areas upstream from where the Elwha dams were constructed. These areas were suitable for holding and spawning (Pess et al. 2008). For 100 years (after 1911), summer steelhead were confined to the lower Elwha River where peak summer temperatures typically reach 18-21°C. As a consequence, this race is now believed by the Puget Sound TRT to be extirpated (PSSTRT 2012). Genetic diversity of the remaining winter-run race of steelhead is further threatened, in

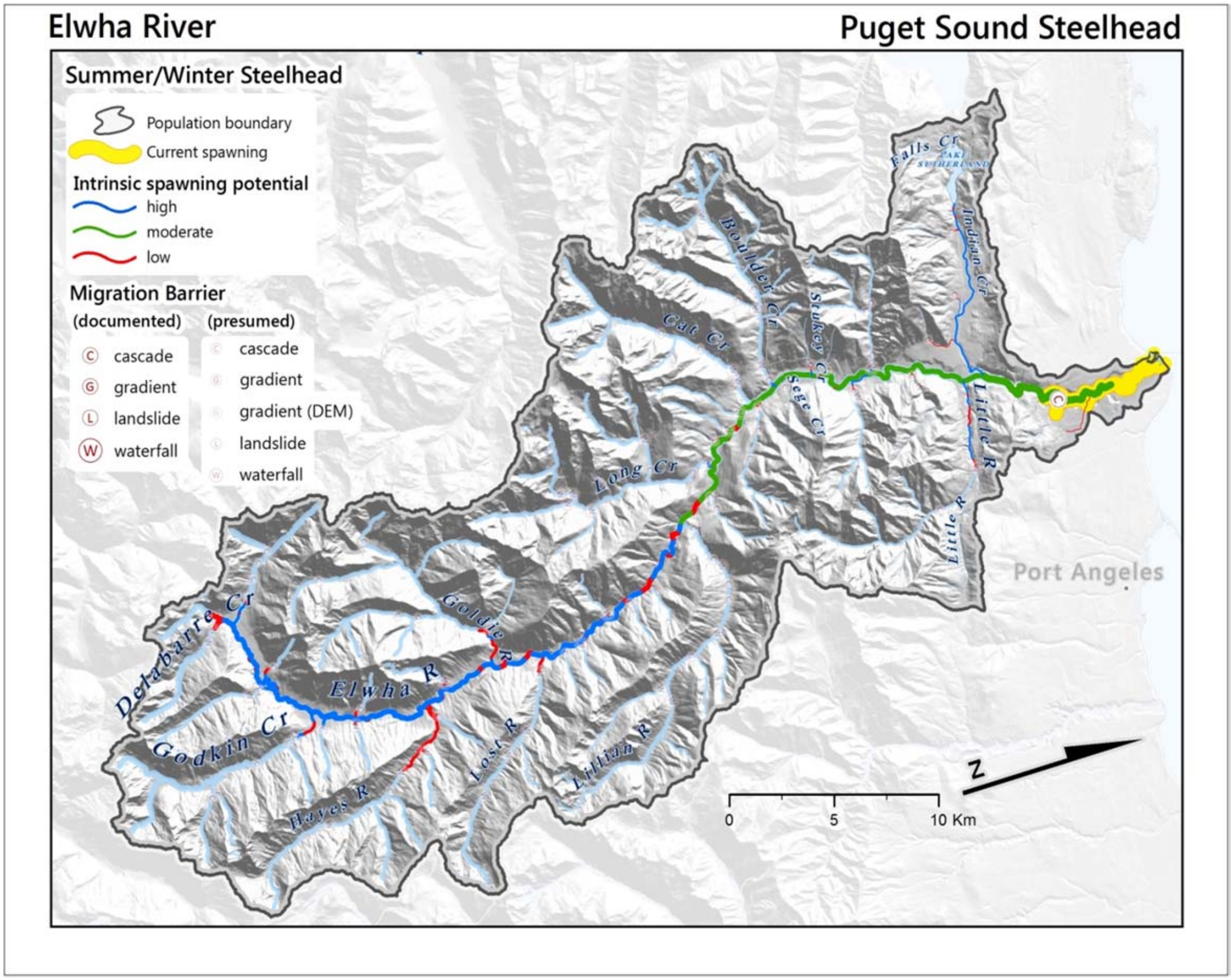

Figure 7. Current spatial structure of the Elwha River steelhead population (yellow highlight) and potential expansion of spatial structure following the removal of the Elwha dams. Source: PSSTRT, 2012.

the short term, by excessive sediment and turbidity levels resulting from the release of stored sediment with dam removal (Beechie et al. 2006; Ward et al. 2008).

Restoration efforts for the species focus on the natural-origin, late-timed, winter-run steelhead component, which is thought to remain genetically representative of the historical native winter-run population (Ward et al. 2008). Genetic analysis indicates that the early-timed portion of the steelhead run is largely derived from the Chambers Creek Hatchery stock. Recent genetic data derived from DNA analysis of four consecutive brood years of late-returning Elwha steelhead indicate that the two populations remain distinct, with no apparent introgression by Chambers stock fish (G. Winans, NWFSC, pers. comm., November 29, 2012). The same analysis showed that the extant Elwha River late-returning steelhead population may be largely supported by straying of wild steelhead into the river from other Puget Sound steelhead populations (e.g., Dungeness). Phelps et al. (2001) suggested that some residualized populations of *O. mykiss* upstream of Elwha Dam were similar to the remnant late-returning anadromous aggregation of the species below the dam. It is unclear if existing resident *O. mykiss* populations (resident *O. mykiss* are not part of the listed Puget Sound Steelhead DPS) contain an anadromous legacy. If so it may take several years following the removal of the Elwha River dams for these populations to reestablish themselves as anadromous and reach some equilibrium with steelhead that are currently spawning below the dam (Phelps et al. 2001).

If summer-run type steelhead are still present in the Elwha River, any remnant population is likely to be at critically low abundance levels (Ward et al. 2008), or reflective of stray hatchery-origin adult returns to the river (PSSTRT 2012). But, the majority of the Puget Sound Steelhead TRT determined that the summer-run race of steelhead in the Elwha River no longer exists (PSSTRT 2012), and that this component of historical diversity has been lost.

The interim restoration goal for steelhead population diversity in the ERFRP is the recovery of natural-origin winter-run and summer-run races (Ward et al. 2008). Diversity triggers established for the Elwha River steelhead population for the preservation and recolonization phases of restoration are no change from baseline traits for allele frequency in selected loci and expected population heterozygosity (Table 4; EMG 2012). Identification of the transition from the recolonization phase to the local adaptation phase of restoration for diversity will be based on the status of other population viability parameters (e.g., steelhead population abundance status).

Productivity

The productivity of the Elwha River late-returning steelhead population is suppressed, with the species recruiting at levels well below replacement. Ford et al. (2011) reported sharply declining short (1995-2009) and long (1986-2009) term population growth rate trends for the late-returning Elwha River steelhead population of 0.75 and 0.84, respectively. Of the Puget Sound steelhead populations analyzed, only Lake Washington steelhead had lower long and short term growth rates than Elwha. NMFS estimated that the probability that the Elwha River steelhead population would decline to 10% of its current estimated abundance (i.e., to 10 fish) is fairly high: ~ 90% within 40 years (NMFS 2011b). They were highly confident ($P < 0.05$) that a 90% decline in the population will not occur within the next 8-10 years (but will occur within 70 years), and that a 99% decline will not occur within 25-30 years (but might occur within 120-150 years).

Under the ERFRP (Ward et al. 2008), the interim restoration target for natural-origin steelhead productivity is > 1.0 recruits per spawner, and 1.8 recruits per spawner at maximum sustainable yield conditions for the population. For the purposes of this opinion, the productivity triggers established by the EMG (EMG 2012) will be used to guide Elwha River native steelhead supportive breeding actions. Productivity triggers for Elwha River steelhead defined by the EMG (2012) for the preservation phase are 75 smolts produced per female, a recruit per spawner rate of > 1.0 (for both spawner to spawner and pre-fishing) as calculated for hatchery plus natural-origin fish returns. For the recolonization phase, and considering only all natural-origin fish, the triggers are 75 smolts produced per female), a spawner-to-spawner recruit per spawner rate of >1.0, and a pre-fishing recruit per spawner rate of >1.56 (Table 4).

Current productivity estimated by Ford et al (2011) is well below the EMG (2012) productivity triggers, and below the population replacement level forthe short and long terms. Achievement of desired steelhead productivity levels is dependent on the condition and pace of recovery of lower river habitat and natural steelhead productivity in available habitat, and the pace of natural fish recolonization and restoration of productivity in newly accessible up-river freshwater environment after the dams are removed. For the short term, the already depressed productivity of the native steelhead population is further threatened by the effects of dam removal, with excessive sediment and turbidity levels expected to form conditions that are inhospitable for steelhead migration and spawning, and egg and juvenile fish survival in available lower river habitat.

Summary of the status of the Elwha River population of Puget Sound steelhead

Puget Sound steelhead continue to be at risk of becoming endangered in the near future and remain threatened under the ESA (76 FR 50448, August 15, 2011). Based on draft DPS viability criteria (Hard et al., pending), it is likely that Elwha River steelhead will be a key or must have population for recovery, needing to be restored to a low extinction risk status. Overall abundance of Elwha River steelhead has declined substantially from historical levels, and the total population is small enough that genetic and demographic risks are high. Diversity of the population has been reduced from historical levels with the loss of the summer-run component of the species, and the long term disconnection and loss of life history forms caused by construction of dams impassable to anadromous fish. The population has been confined to about 4.9 miles of spawning area, relative to the 90 miles of river habitat historically accessible, and disruption of population spatial structure has been severe. Adverse effects on productivity associated with confinement of spawning to a degraded lower river area with no viable estuary are evidenced by sharply declining growth rate trends over both the short and long terms. Over the short term, viability of the natural population and the lower river habitat sustaining it are further threatened by the effects of dam removal. The abundance, spatial structure, diversity, and productivity of the remaining natural population would be expected to become further impaired from current conditions through the release of stored sediments behind the dams as they are removed. Over the long term, the viability status of the population should improve substantially as lower river and estuary habitat recovers, and as steelhead remaining after the dam removal period recolonize and become productive in newly accessible upper Elwha River areas.

2.2.3. Eulachon

The region-wide status of the southern DPS of Pacific eulachon is described in the Federal Register Notice designating eulachon as a threatened species (75 FR 13012 March 18, 2010) and the NMFS "Status Review Update for Eulachon in Washington, Oregon, and California" (Gustafson et al. 2010). The listed DPS is composed primarily of spawning aggregations in three large rivers: the Klamath, lower Columbia, and Fraser. Smaller spawning aggregations occur in several other Pacific Northwest rivers, from north of Mad River, California to coastal British Columbia rivers south of the Nass River (Gustafson et al. 2010). The primary threats to eulachon DPS viability are changing ocean conditions and altered freshwater habitats. Additionally, eulachon status is affected by habitat-based threats such as those resulting from water impoundment and water diversions that reduce available habitat and stream flow, and alter the composition of river substrates that are important for spawning eulachon.

Eulachon in the listed southern DPS are primarily a marine, pelagic species that spawn in the lower reaches of coastal rivers and whose primary prey is zooplankton (Gustafson et al., 2010). They are typically found "in near-benthic habitats in open marine waters" of the continental shelf between 20 and 150 m depth (Hay and McCarter 2000). In Puget Sound the species is found almost exclusively in the Strait of Juan de Fuca and San Juan Islands (W. Palsson, WDFW, unpubl. data). Eulachon are caught in targeted commercial fisheries in the Columbia River basin using small-mesh gillnets (i.e., <2 inches stretched mesh) and small mesh dip-nets (although small trawl gear is legal, it is rarely used). Eulachon have been taken as bycatch in pink shrimp trawl gear off the coast of Oregon, Washington and California, and in Puget Sound (W. Palsson, pers. comm., WDFW, Fish Biologist). Salmon fisheries in the northern Puget Sound areas use nets with large mesh sizes (i.e., >4 inches) and hook and line gear designed to catch the much larger salmon species. The gear is deployed to target pelagic feeding salmon near the surface and in mid-water areas. Encounters of eulachon in salmon fisheries would be extremely unlikely given the general differences in eulachon and salmon size, spatial distribution, and fishing gear characteristics used to harvest the species.

Eulachon presence in Puget Sound region watersheds is considered rare. Eulachon use the surrounding Columbia and Fraser River watersheds for reproduction (Bargmann 1998; Gustafson et al. 2010). Recorded observations of eulachon in the Elwha River indicated abundance levels for the species in the river in the hundreds, probably well below the spawning aggregation size that would be necessary for long-term stability (Schaffer et al. 2007; Gustafson et al. 2010). Small numbers of maturing eulachon (10 to 50 per year) have been recorded more recently through salmon smolt trapping studies in the Elwha River (M. McHenry, Lower Elwha Klallam Tribe, pers. comm., March 12, 2010). The capture of 58 adult eulachon was reported in the Elwha River between March 18 and June 28, 2005 (WDFW 2012). The average individual sizes of eulachon collected in the Elwha River in 2005 were 160 mm (fl) for females and 180 mm (fl) for males (Gustafson et al. 2010). Since 2005, adult eulachon have been captured in the Elwha River every year (2006–2010) in the Lower Elwha Tribe’s rotary screw trap (LEKT unpublished smolt trap data, 2010). Salmon smolt trapping in the Elwha River has shown that eulachon migrate into the Elwha River in small numbers (as indicated by trap counts of 10 to 50 fish per year) in the late winter or early spring (M. McHenry, Lower Elwha Klallam Tribe, pers. comm. March 12, 2010). Eulachon trapped in the Elwha River in 2010 were gravid, but it is unknown whether the species spawns in the river. Larval sampling studies are needed to determine whether the species is successfully reproducing. Despite the occasional presence of eulachon in the Elwha River, the relatively small numbers of straying fish are not likely to be successfully contributing to the annual recruitment of juveniles that would substantially support recovery of the DPS (Gustafson et al. 2010).

Substrate composition in the lower Elwha River is currently quite coarse as a result of decades-long disruption of natural sediment routing processes caused by the Elwha dams. Sediment retention by the dams is most likely responsible for increased grain size in the lower Elwha River that limits the amount and availability of preferred spawning habitat for eulachon, which is sand and small gravel. Furthermore, the presence of the lower dam prevents access to potential spawning areas above the action area. Thus, habitat in the Elwha River available for eulachon is presently degraded and poorly suited for eulachon spawning.

2.2.4. Status of Critical Habitat

We review the status of designated critical habitat affected by the proposed action by examining the condition and trends of essential physical and biological features throughout the designated area. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging (Table 12).

Table 12. Essential physical and biological features named as PCEs in critical habitat designations for Chinook salmon and eulachon.

Site	Essential Physical and Biological Features	Species Life Stage
Freshwater spawning	Water quality, water quantity, and substrate	Spawning, incubation, and larval development
Freshwater rearing	Water quantity and floodplain connectivity Water quality and forage Natural cover	Juvenile growth and mobility Juvenile development Juvenile mobility and survival
Freshwater migration	Free of artificial obstructions, water quality and quantity, and natural cover	Juvenile and adult mobility and survival
Estuarine areas	Free of obstruction, water quality and quantity, and salinity Natural cover, forage, and water quantity	Juvenile and adult physiological transitions between salt and freshwater. Growth and maturation
Nearshore marine areas	Free of obstruction, water quality and quantity, natural cover, and forage	Growth and maturation, survival
Offshore marine areas	Water quality and forage	Growth and maturation

Notes: Natural cover includes shade, large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Forage includes aquatic invertebrate and fish species that support growth and maturation.

For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each listed species they support[3]; the conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' critical habitat analytical review teams (CHARTs; NOAA Fisheries 2005) evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or the fact that it serves another important role (e.g., obligate area for migration to upstream spawning areas).

Chinook salmon

Critical habitat for Puget Sound Chinook salmon extends throughout the action area, including the Elwha River mainstem and tributaries above and below the dam sites. As described in NMFS (2006a), in summary, all PCEs except offshore marine areas are present within the action area.

[3] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (CHART 2005).

Only nearshore marine areas are presently functioning at a level that can sustain a naturally viable population of listed Chinook salmon. Freshwater migration to historical spawning and rearing habitat has been substantially obstructed by the Elwha dams. Of the PCEs within residual rearing and spawning habitat below the Elwha Dam site, water quality is degraded by temperature accounting for a number of pre-spawner adult mortalities each year and substrate has degraded because the dams have interrupted fluvial transport and mostly only larger cobbles remain downstream of RM 4.9. Only remnant spawning substrate remains in one lower river side channel. Dikes and levees in the lower river limit connectivity to the floodplain and prevent access of Chinook salmon to flood channels during high water events where important prey resources for the species exist. Within the estuary, water quality is similarly degraded by warm temperatures that may impair adult returns. Natural cover for forage and predator avoidance is limited by lack of recruitment of large woody debris and dike maintenance that precludes establishment of vegetative cover. Nearshore marine areas have been reduced in size due to interrupted fluvial transport of sediments. Lack of this recruitment has resulted in steepened beaches and a substantially modified biotic community. Disrupted fluvial sediment transport has eliminated much of the refugia, forage and migratory habitat for juvenile Chinook salmon in the nearshore area. More specific information regarding habitat conditions within the action area are found in the environmental baseline section, below.

In the critical habitat designations, NMFS published lists of PCEs for salmon and steelhead (Table 12). These PCEs include sites essential to support one or more life stages of the Puget Sound Chinook salmon ESU (sites for spawning, rearing, migration, and foraging). These sites in turn contain physical or biological features essential to the conservation of the ESU. Specific types of sites and the features associated with them include: (1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks; (3) Freshwater migration corridors free of obstruction, with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival; (4) Estuarine areas free of obstruction, with water quality, water quantity and salinity conditions supporting juvenile and adult physiological transitions between fresh-and saltwater; natural cover, such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation; (5) Nearshore marine areas free of obstruction, with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and (6) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation (CHART 2005).

Eulachon

NMFS designated critical habitat for the southern DPS of Pacific eulachon on October 20, 2011 (76 FR 65324). Critical habitat for eulachon includes discrete watershed areas in California, Oregon, and Washington as identified in 76 FR 65324. NMFS delineated each specific watershed area as extending from the mouth of the river or creek (or its associated estuary when applicable) upstream to a fixed location where eulachon were known to be present. In designated freshwater areas, critical habitat includes the stream channel and a lateral extent as defined by the ordinary high-water line (33 CFR 329.11). In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bank-full elevation. Bank-full elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge that generally occurs every 1 to 2 years in the annual flood series. In estuarine areas, critical habitat includes tidally influenced areas as defined by the elevation of mean higher high water.

The physical or biological features essential for conservation of the southern DPS of Pacific eulachon are: (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation; (2) freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted; (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

The Elwha River downstream of Elwha Dam to the mouth of the river is included as part of designated critical habitat for the listed species. The upstream limit of critical habitat terminates at the Elwha Dam site, as watershed areas upstream of that location were unlikely to have had eulachon prior to dam construction due to natural barriers. Elwha Dam was built at a site where the river is confined to a narrow canyon, with high gradient and water velocities that likely prevented upstream passage of eulachon. NMFS was unable to find information supporting eulachon presence above the dam site prior to its construction in 1911. The downstream critical habitat boundary for the Elwha River was defined as a line drawn from the easternmost seaward extremity of the mouth of the river to the westernmost seaward extremity of the mouth (76 FR 65324).

NMFS determined that designation of critical habitat for eulachon on Indian lands would have an impact on federal policies promoting Tribal sovereignty and self-governance. It would also have an impact on the relationship between NMFS and each of the Tribes because of their perception that designation is an intrusion on Tribal sovereignty and self-governance. Indian lands of the Lower Elwha Klallam Tribe overlap with approximately 1.4 miles or 29% of the areas occupied by eulachon in the Elwha River. These lands were excluded from the critical habitat designation for eulachon (76 FR 65324).

Essential habitat features for eulachon critical habitat mirror those identified for other anadromous fish species, like salmon and steelhead (76 FR 65324, October 20, 2011). The current state of critical habitat for the species is essentially the same as conditions identified for Chinook salmon, above.

2.2.5. Climate Change

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

- Warmer air temperatures will result in a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a shift to more rain and less snow, snow-packs will diminish in those areas that typically accumulate and store water until the spring freshet.
- With a smaller snowpack, runoff will be diminished and exhausted earlier in the season, resulting in lower stream flows in the June through September period.
- River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures will continue to rise, especially during the summer months when lower stream flow and warmer air temperatures will contribute to the warming regional waters.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Areas with elevations high enough to maintain temperatures well below freezing for most of the winter and early spring would be less affected. Low-lying areas that historically have received scant precipitation contribute little to total stream flow and are likely to be more affected. Projected climate changes may have long-term effects that include, but are not limited to, depletion of cold water fish habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated salmonid embryo development, premature emergence of fry, and increased competition among salmonid species (ISAB 2007).

Simulations of climate change effects on Washington watersheds completed by Mantua et al. (2009) predict slightly increasing water temperatures and thermal stress for salmon inhabiting western Washington watersheds through 2030, with increasingly large changes in these factors occurring later in the 21st century. Stream flow simulations predict that the largest hydrologic sensitivities are for watersheds that currently have so-called transient runoff stream flows; those that are strongly influenced by a mix of direct runoff from autumn rainfall and spring-time snowmelt like the Elwha River. By 2080, hydrologic simulations by Mantua et al (2009) predict a complete loss of snowmelt dominant basins in Washington, and only about 10 basins remaining in the north Cascades classified as transient snow basins. Historically transient runoff watersheds like the Elwha River will trend towards rainfall dominant basins and experience longer summer low flow periods, increased stream flow in winter and early spring, declines in the magnitude of summer low flows, and increases in winter flooding (Mantua et al. 2009; USDA 2011). The combined effects of warming stream temperatures and altered stream flows will very likely reduce the reproductive success and rearing habitat for salmonid populations in the Elwha River watershed, but impacts will vary according to different life history-types (Mantua et al., 2009; USDA 2011). Salmonid populations having a stream type life history with extended freshwater rearing periods (i.e. Elwha River steelhead and coho salmon) are likely to experience large increases in hydrologic and thermal stress in summer due to diminishing stream flows and increasingly unfavorable stream temperatures. Increased mortality rates may be expected during spawning migrations for adult fish returning during the summer months, like Elwha River Chinook salmon. Salmonids with an ocean-type life history and relatively brief freshwater rearing periods (i.e. Elwha River Chinook, pink, and chum salmon) are predicted to experience the greatest freshwater productivity declines in transient runoff watersheds where future warming is predicted to increase the magnitude and frequency of winter flooding (USDA 2011) that reduces egg-to-fry survival rates (Mantua et al. 2009).

2.3. Environmental Baseline

The ‘environmental baseline’ includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). An environmental baseline that does not meet the biological requirements of a listed species may increase the likelihood that adverse effects of the proposed action will result in jeopardy to a listed species, or, in destruction or adverse modification of designated critical habitat.

NMFS describes the environmental baseline in terms of the condition of the habitat features and processes necessary to support life stages of each listed species within the action area. The type and condition of salmon habitat in the action area varies depending on the life history stage present and the natural range of variation present within the system (Groot and Margolis 1991; NRC 1996; Spence et al., 1996). For this action area, the biological requirements for Puget Sound Chinook salmon, Puget Sound steelhead, and eulachon are the habitat characteristics that support successful spawning, rearing and migratory habitat. The condition of Chinook salmon, steelhead, and eulachon habitat in the action area reflects environmental alteration in the manner described below.

2.3.1. Pre-Dam Removal Conditions

The Elwha River is the largest and historically the most productive river within the Strait of Juan de Fuca region (this and following text from NMFS 2006a; Ward et al. 2008; Pess et al. 2008; Duda et al. 2008; 2011; Haring 1999). The river has a mean annual flow of 1,508 cubic feet per second, and drainage area of more than 270 square miles. The Elwha River flows northward from the Olympic Mountains to the Strait of Juan de Fuca near the town of Port Angeles, Washington. The upper watershed of the Elwha River is located within Olympic National Park and within a Wilderness Area (DOI 1996).

Private companies constructed two large dams during the early 1900s. Construction of the Elwha Dam began in 1911 and was completed in 1913 at RM 5. This dam was 105 foot high and impounded Lake Aldwell. At RM 13.3, Glines Canyon Dam, built in 1927, was a 210-foot high concrete dam that formed Lake Mills. When the dams were first built, they were important producers of electricity on the Olympic Peninsula. These two large dams were constructed with no facilities providing for the upstream passage of anadromous fish, preventing retuning adult fish from reaching their historical spawning grounds and rearing areas. The dams eliminated up-river production of coho salmon, Chinook salmon, winter and summer-run steelhead, pink salmon, and the anadromous form of char.

Numbers of Chinook salmon (and other species of Pacific salmon – coho, pink and chum, as well as sea-going trout such as steelhead) have been declining in the watershed over the last century. Most of the habitat of the upper Elwha River is in excellent condition, because 83 percent of the watershed lies within Olympic National Park and is managed to maintain natural conditions.

The Elwha River is classified as “extraordinary” quality water by the Washington State Department of Ecology. However, the Elwha River is on the Clean Water Act 303(d) List of impaired water bodies for temperature. Summer temperatures appear to be three to six degrees higher than normal, as the reservoirs behind Elwha and Glines Canyon dams have acted as solar “heat sinks”, warming the river (DOI 1995). As noted previously, Chinook salmon spawn in the Elwha River beginning in late August. Unless they are able to find areas where cold water seeps can cool the eggs, embryos of these earliest spawners may not survive in temperatures warmer than 13° C. With the exception of temperature, water quality in the upper Elwha River, and in the lower river prior to removal of the dams beginning in 2011, was generally excellent, providing domestic and industrial water to the City of Port Angeles, the Tribe, and several small community-based systems.

For 100 years, the Elwha Dam has prevented passage of anadromous salmonids, including listed Chinook salmon and late-returning steelhead, beyond the first 5 miles of river. In addition, both dams in the watershed have prevented the natural transport of gravel, sand and other sediment downstream impairing the functional condition of spawning habitat below the dams (Pess et al. 2008) and the functional condition of habitat in the estuary. This stretch of river is also unnaturally heated in late summer and early fall by the “heat sink” effects of Lake Aldwell and Lake Mills.

The stretch of river below the dams is also largely lacking the organic debris and nutrients it historically contained. Organic debris formerly came from tree boles, limbs and leaves from the upper river. Much of the nutrients came from the vast number of salmon carcasses that once filled the river and lined its banks. Loss of minerals, nutrients and organic materials has reduced productivity, including insects and aquatic invertebrates that serve as food for Chinook salmon and other salmon and trout species. Historical estimates of the total anadromous salmonid population in the Elwha River prior to dam construction range from 380,000 to 500,000 fish (DOI et al. 1994, DOI 1996, Munn et al. 1999). Only about 5,500 fish, mostly of hatchery-origin, escape to the river now. Instead of occupying approximately 90 miles of high quality mainstem and tributary habitat, returning adult salmon and steelhead have been confined within the lower 4.9 miles, and in conditions of low productivity and sometimes impaired water quality.

When the dams eliminated Chinook salmon, steelhead, and other salmonids in the middle and upper river, they altered the Elwha River aquatic and upland ecosystem as well. The tens of thousands of Chinook salmon, in addition to the hundreds of thousands of all Pacific salmon and trout that once returned to the river, served as a year-round dependable food source and nutrient base for other wildlife and to the continual production of insects and other salmonid prey species. In less impaired watersheds, salmon carcasses can contribute as much as 40 percent of the body weight of aquatic insects and small fish (Sims 1994).

The reservoirs inundated more than five miles of stream and riparian vegetation and the dams held back natural transport of sediment and large wood. The reservoirs and their effects have fundamentally altered river morphology and processes in ways that reduce fish productivity. Gravel and sand in the riverbed provided habitat for insects, aquatic species, and spawning salmon, including Chinook salmon and steelhead. Pre-dam conditions were naturally dynamic, with high natural sediment loads that made the river shift channels, scouring vegetation from banks and floodplains, contributing large woody debris, and further adding to the complexity and overall productivity of fish habitats. Currently accessible riverine habitat for Chinook salmon, steelhead, and other anadromous salmonids below the dams has low aquatic productivity, and is armored and channelized. The channel has shrunk in width, incised vertically, and the riverbed has become armored with cobbles and boulders (Gilbert and Link, 1996 and Haring 1999). The only remaining sediment sources to the lower Elwha River are from lateral erosion of floodplain and terrace banks along the river. Presently, the lower-most three miles of the mainstem Elwha River flow through a meandering cobble and boulder-bed river channel with pools and riffles. Consequently, spawning habitat in the lower river for Chinook salmon and other salmonids is a limiting factor. While the dams immediately eliminated upriver production of spring Chinook salmon and other salmonids, some lower river stocks such as pink and chum salmon remained at relatively high abundance into the mid-1960s. However, the ecological changes described above led to the collapse of these stocks by the 1970s (Haring 1999; and Good et al., 2005).

Channel conditions in the lower river are adverse for fish. Levees and dikes constrain the channel at seven sites and reduce the river’s access to the floodplain. Loss of seasonal floodplain fish habitats, and the inability of the river to form alternate channels, has further degraded habitat complexity leading to reduced rearing opportunity for juvenile Chinook salmon, steelhead and other salmon species as they move into the estuary and marine environment. Within the leveed channel, the river repeatedly experiences scouring and filling with sediment on the scale of hours and days, creating unproductive conditions for spawning, incubation and rearing of Chinook salmon, steelhead, and eulachon. The few sites of good quality side-channel habitat that occur in the lower river are used by both adult and juvenile salmonids. Abundant large wood was critical to habitat forming processes in the lower river. The lower Elwha River formerly harbored many very large logjams that provided important habitat to anadromous fish, including Chinook salmon and steelhead. However, large wood is chronically deficient in the Elwha River below Elwha Dam. Large wood recruited from upstream sources until very recently (2012, with full removal of Elwha Dam) has not been transported through the reservoirs. Also, riparian trees have been prevented from growing on levees along the lower river.

The high capture rate of river-borne sediments by the two Elwha River dams and their reservoirs changed the geomorphology of the riverbed downstream of the dams (Duda et al. 2008). It is estimated that about a quarter of a million cubic yards of material above the dams was prevented from reaching the estuarine and nearshore environments each year (DOI 1996). Recent estimates indicate that a combined volume of approximately 23 million cubic yards of sediment had accumulated behind the dams in Lake Mills and Lake Aldwell (Bountry et al., 2010; Czuba et al, 2011, cited in Duda et al. 2011). While the dams have not appreciably changed the total amount of water or eliminated peak flows to the river's mouth, the dams have starved the lower river of gravel important as fish habitat, impairing salmon and steelhead survival and productivity. The river's estuary and nearshore marine environment[4] have also been starved of sediment to the detriment of salmonid habitat, contributing to the erosion and steepening of beaches to the east, altering and in some cases eliminating habitat for other aquatic wildlife. Like the river channel, the estuary has degraded with at least 1,200 feet of shoreline eroded (Haring 1999). Based on results of a survey in the summer of 1994, marine resources near the Elwha River mouth are affected primarily by substrate, slope, depth, and wave action (Seavey and Ging, 1995). The mid to upper portion of the intertidal zone near the river mouth consists of a steep beach with coarse substrate subject to high wave action.

One of the most important habitats for Chinook salmon early life history is the estuary. Properly functioning estuaries are among the most productive natural aquatic systems, and are important nursery areas for a variety of fish and shellfish species that provide food and refuge from predators. Juvenile Chinook, coho, pink and chum salmon may use estuaries for months, feeding and growing at their most rapid rate before moving into deeper marine water. Juvenile Chinook salmon, and other Pacific salmon and anadromous species rely on estuaries to help them transition from a freshwater to a marine existence. In a properly functioning estuary, sediment carried by a river with unrestricted transport is deposited in marine waters offshore, typically forming a bar that keeps salt water out during low tides. This process creates a zone of brackish water where fresh and saltwater mix.

As described above, the greatest impact on the Elwha River estuary from the dams has been the disruption of river sediment transport processes. Because of this disruption, the function of the Elwha River estuary has become greatly reduced for Chinook salmon, steelhead, and other fish species. A large area of shallow beach, where fresh and salt water mix, is notably absent at the mouth of the Elwha River. Much of the Elwha River estuary has been altered by diking. The historical low-gradient habitat of the estuary and salt marsh tidal channels (found to be vital for ocean-type juvenile Chinook salmon rearing) has been virtually eliminated at the mouth. Hundreds of acres of this important habitat have been lost (Crain et al., 2004). The armoring of the feeder bluffs to the east of the river mouth beginning in the 1930s has further degraded the Elwha nearshore. At present nearly 9,000 feet of the Elwha nearshore is armored, while the western estuarine habitat at the river mouth was truncated by the 1965 construction of a flood protection levee (Ward et al. 2008). After decades of sediment reduction, due to the dams and river-bank armoring, the adjacent nearshore seafloor has coarsened (Warrick et al., 2008, cited by Duda et al., 2011) and appears to have developed benthic communities characteristic of

[4] This area includes the area of tidal influence to 30 m MLLW (mean lower low water) and tidally influenced portions of the riparian zone. Habitats of the Elwha nearshore include the lower river and associated estuary, intertidal and shallow subtidal sand, and cobble habitats.

coarse sediment and hard bottom substrate (Rubin et al., 2011). In addition, erosion and steepening of the beach further to the east of the river mouth along Ediz Hook has led to placement of large riprap along and above the intertidal zone for property protection purposes. These actions further reduced the natural habitat complexity for aquatic biota. Purposeful and natural alterations to the nearshore marine habitat, particularly the steepening of beaches and subsequent armoring, have adversely affected juvenile salmon and steelhead refugia, and the quantity and quality of rearing areas and migratory corridors for salmonids.

2.3.2. During and Near Term Post-Dam Removal Conditions

Mobilization and downstream transport of sediments accumulated in the Lake Mills and Lake Aldwell during and following dam removal is likely to substantially change reaches in the lower Elwha River, its estuary, and the nearshore environment adjacent to the river mouth (this and following generally from Duda et al. 2011; Ward et al. 2008; and NMFS 2006a). Sediment transport in the Elwha has gone from too little to too much – the material that normally would have fed the system for a hundred years is now rushing downstream all at once. As dam removal proceeds, fine sediments are suspended in the reservoirs and transported downstream. Critical salmon and steelhead habitat downstream of the dams is currently being degraded or destroyed as substantial increases in suspended sediment supply increased turbidity levels, making water quality conditions inhospitable for fish in mainstem reaches. During the first three weeks of November 2012, when a hiatus in dam deconstruction activity was in place to foster reduced turbidity during the adult coho salmon and steelhead migration periods, turbidity has nonetheless ranged from 1700-5400 nephelometric turbidity units (NTU, similar to the common parts per million (ppm)) in the middle Elwha River and 1400-5300 NTU in the lower Elwha River, averaging about 2,300 NTU in both river reaches where fish are currently migrating or rearing (USGS Sediment Monitoring Data, November, 28, 2012). These turbidity levels are much higher than modeled levels for this period. Side-channel habitats in the lower and middle rivers areas were expected to be somewhat buffered to an unknown degree from sediment effects and may offer refugia for fish present. However, although NMFS scientists monitoring the river report that some of these side-channels do currently have clear water relative to the mainstem river, flows in those areas are merely trickles running over broad mud flats, so habitat is not very conducive for fish survival (George Pess, NMFS, pers. comm. November 28, 2012). There are some other side-channel areas accessible to fish that remain intact at present, but one is losing its water source, presumably through fine sediment plugging of the channel's connection to its river flow source. The few side-channel refugia for natural salmon and steelhead rearing that are connected to the river are also filling, to the detriment of natural fish survival. Studies of the reservoir sediment composition indicated that 85 percent and 95 percent of accumulated materials in Lake Mills and Lake Aldwell, respectively, were fine sediment - sand, silt, and clay (DOI 1995; Randle et al. 1996; Childers et al. 2000, as cited in Duda et al. 2011).

A portion of this stored fine sediment, mobilized in the water column during and immediately after dam removal, has resulted in extremely high suspended-sediment concentrations in the Elwha River downstream of the Elwha Dam site. During the initial phases of removal, it is anticipated that turbidity (suspended sediment) levels will exceed 1,000 parts per million (ppm) for extended periods of time (as is currently occurring) and will spike to levels exceeding 10,000 ppm for several weeks each year, with periodically high concentrations for as much as 3 to 5 years following dam removal (Randle et al., 1996; Ward et al. 2008; Duda et al. 2011). In response to removal of approximately 2/3 of Glines Canyon Dam, suspended sediment levels are already periodically exceeding 5,000 ppm (USGS Sediment Monitoring Data, November, 2012)). The high sediment loads will cause deleterious effects in the egg to outmigrant fry stage for all species of fish present in the lower watershed (Pess et al., 2008). Fish exposed to sediment loads between 50 and 100 ppm for an extended period of time may stop feeding, suffer gill abrasion, and experience loss of fitness due to the associated stress (Cook-Tabor 1995). At turbidity levels above 1,000 ppm, direct mortality of fish may result simply from the elevated sediment loads (Cook-Tabor 1995). With sediment loads expected to exceed 10,000 ppm, it was assumed for salmonid population recovery planning purposes that most or all fish rearing naturally in the Elwha River below the former site of Glines Canyon Dam will be killed by stored sediment released during and for an unknown number of years following dam removal (Ward et al. 2008).

In addition to fine sediment loading, coarser sediments stored behind the dams are overwhelming habitat downstream, including the only refugia left for the fish, This condition is expected to persist for up to 10 years (BOR 1996). It is anticipated the stream channel below the dams may destabilize during this time, with a resultant temporary decrease in quality of the natural fish habitat. Over the long-term, the Elwha River bed downstream of the dams was expected to aggrade by as much as 1 to 4 feet in some areas (Ward et al. 2008; Duda et al. 2008; 2011). These expectations for sediment transport are being realized. Recent observations by NMFS NWFSC staff indicate that as much as 10 feet of material has already overwhelmed portions of the lower river (George Pess, NMFS, pers. comm. November 28, 2012). Aggradation levels at these amounts will affect channel morphology by increasing the width to depth ratio of the channel cross section, filling pool habitat used by juvenile and adult fish, and reducing the quality of rearing habitat (Ward et al. 2008). Interstitial filling of the gravel beds with fine sediment will be another result, degrading spawning areas. Mobilized sediment transported downstream and into marine waters of the Strait of Juan de Fuca should have both adverse and beneficial effects, as it is dispersed by waves and tidal currents and deposited on sediment-starved beaches and the seafloor of the Elwha delta (Warrick and others, 2011, cited in Duda et al. 2011).

The likelihood for high suspended sediment concentrations led to implementation of risk reduction measures for the Elwha Fish Restoration Project (Ward et al. 2008). These measures include construction of new surface water-treatment facilities to reduce turbidity levels for fish reared on river water in downstream hatcheries, suspension of dam deconstruction activities to create “fish windows” that would protect migrating adult salmon and steelhead from excessive turbidity, and the operation of hatcheries to preserve remaining native fish stocks through supportive breeding.

Dam removal has unleashed a hundred years of stored sediment, resulting in turbidity and sediment transport levels that are unprecedented and that pose a substantial threat to salmon and steelhead survival, especially considering their already threatened status. This is the beginning of a healing process that, after an initial shock, will lead to more normative processes and conditions under which salmon and steelhead are known to thrive. In the mean-time, course and fine material stored behind the dams for 100 years is now supplying sediment to the lower river and to the estuary. Some years will likely be required to reach an equilibrium between sediment supply and transport capacity (Ward et al. 2008). Dam removal is expected to almost immediately correct elevated water temperature conditions throughout the lower river caused in the past by thermal warming in the reservoirs that adversely affected fish migrating in the summer months. But dam removal is not expected to affect the deficit of large woody debris in mainstem areas associated with past intentional removal, logging, and channelization (but see section 2.5.3 for remedial actions). Additionally, the reservoir areas formed by the dams were logged prior to dam construction, and at least 6 miles of the Elwha River main-stem will therefore have little input of large wood beneficial for fish for several decades. The reservoir areas will likely remain highly unstable for several years following dam removal (Ward et al. 2008).

There is no template available for a similarly scaled dam removal project that can be used to indicate the pace of watershed habitat and salmonid population recovery. For these reasons, the duration of time required for the lower river areas and the estuary to recover to properly functioning statuses, conducive to the support of natural-origin salmon and steelhead population abundance and productivity at viable, self-sustaining levels, is highly uncertain.

Also included as part of the environmental baseline were several ESA consultations completed by NMFS that comprise Federal actions affecting the condition of habitat features and processes supporting listed Elwha River Chinook salmon, steelhead, and eulachon. The effects of habitat alteration on listed fish resulting from deconstruction of the Elwha River dams were evaluated through three section 7 consultaitons with NPS (NMFS 2006a; 2010b; and 2012a). NMFS completed its initial consultation with NPS on the effects of dam removal activities on listed Chinook salmon in 2006, concluding that the action, as proposed, is not likely to jeopardize the continued existence of Puget Sound Chinook salmon or Puget Sound steelhead, and is not likely to destroy or adversely modify designated critical habitat for Puget Sound Chinook salmon (NMFS 2006a). As described in section 1.2, as a term and condition of its authorization of the NPS actions, the 2006 ITS provided that the NPS must rescue and remove adult Chinook salmon from the Elwha River and move the fish to the WDFW rearing channel or to the Lower Elwha Klallam Tribe's hatchery to provide broodstock for the supportive breeding programs, or to unaffected river habitat above the dam sites, to reduce the level of take from sediment releases.

Through a reinitiation of formal consultation for the Elwha River Ecosystem and Fisheries Restoration Project, NMFS evaluated effects on southern distinct population segment (DPS) of eulachon (NMFS 2010b). The need for the reinitiated consultation was triggered by the addition of the southern distinct population segment (DPS) of eulachon to the list of species protected as threatened under the ESA, because eulachon were not previously considered in the original consultation. In a subsequent reinitiated consultation regarding dam removal effects on listed fish, NMFS completed a second biological opinion on the Elwha River Ecosystem and Fisheries Restoration Project in 2012, which superseded the 2006 opinion (NMFS 2012b). The 2012 opinion incorporated NMFS' earlier findings with updated information to newly address take of listed steelhead, which had been listed as threatened in 2007 after completion of the initial NMFS (2006a) opinion (NMFS 2012a). NMFS also provided a refreshed take statement applicable to Chinook and steelhead, as well as other changes through the updated consultation. In reaching a "no jeopardy" conclusion, NMFS included a term and condition requiring removal of steelhead from the river to for use as broodstock in supportive breeding at the LEKT hatchery

(LEKT 2012a) or for transport upstream into unaffected areas, to minimize listed fish take associated with the sediment transport and turbidity effects of dam deconstruction.

In 2011, NMFS completed a consultation regarding the effects of Puget Sound salmon and steelhead fisheries harvest on listed fish that addressed harvest effects on Elwha River Chinook salmon and steelhead (NMFS 2011b). NMFS reviewed the resource management plan entitled, "Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component" (PSIT and WDFW 2010) and found that the plan did not appreciably reduce the likelihood of survival and recovery of the Puget Sound Chinook salmon ESU and that the plan adequately addressed the criteria established for Limit 6 of the ESA 4(d) Rule for the listed Puget Sound Chinook salmon ESU. Harvests occurring in steelhead-directed fisheries were also determined to be adequately protective of listed fish, including fisheries directed at Chambers Creek steelhead in the Elwha River.

2.3.3. NMFS Funded Habitat Improvement Programs

Throughout Puget Sound, NMFS funds several large-scale habitat protection and restoration programs designed to benefit the future status of the listed species and their designated critical habitat considered in this opinion. These programs, which have undergone Section 7 consultation, provide non-Federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using Federal funds, it can be difficult to distinguish between projects with a Federal nexus and those that can be properly described as Cumulative Effects. As a result, many of the projects submitted by the State of Washington as cumulative effects actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007b), and the Restoration Center Program (NMFS 2004a). The objectives of these programs are described below. To avoid duplication of previous assessments of effects, NMFS considered the projects submitted by the state as cumulative effects (Section 2.5).

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats (NMFS 2007b). The states of Washington, Oregon, California, Idaho, and Alaska, and the Puget Sound, Washington Coast, and Columbia River tribes receive Congressional PCSRF appropriations from NMFS each year. The fund supplements existing state, tribal, and local programs to foster development of Federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NMFS has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho, and Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, and the Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made important progress in achieving program goals, as indicated in Reports to Congress, workshops, and independent reviews.

NOAA Restoration Center Programs

NMFS has consulted with itself on the activities of the NOAA Restoration Center (RC) in the Pacific Northwest (NMFS 2004a). These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program that helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Summarized in the ERFRP (Ward et al. 2008) are habitat restoration projects funded through federal sources that have been implemented, or are planned for implementation, in the Elwha River watershed to assist habitat recovery during and after dam removal. The LEKT implemented several small scale habitat restoration projects in the mid-1990s, focusing on lower river side-channel habitats, including Bosco and Boston Charley creeks. One project re-established flows in Bosco Creek, resulting in increased natural production of steelhead and coho and chum salmon (LEKT 2006). More recent restoration projects included restoration of floodplain features through construction of engineered logjams, flood-plain reforestation, and removal of impediments to channel migration in the floodplain (e.g., levees). Through 2005, 22 logjams were constructed in the mainstem Elwha River, providing stable and cost effective improvement of fish habitat. Planned additional restoration actions include installation of more engineered log jams, flood-plain reforestation, removal or modification of floodplain dikes, and acquisition of floodplain habitat for long-term conservation. Funding support for previously implemented and planned habitat restoration efforts, and actions taken to monitor project effects on Elwha River salmon and steelhead was provided through the SRFB process and direct appropriations from Congress.

NMFS believes that these projects will benefit the viability of natural-origin salmon, steelhead, and eulachon in the Elwha River by improving their abundance, productivity, and spatial structure. The projects should assist the populations in becoming self-sustaining, commensurate with the implementation, and eventual, planned phase-out of supportive breeding actions evaluated in this opinion. Some habitat restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Other types of Federal projects, including flood protection and bank stabilization actions, will have neutral, or perhaps short- or even long-term adverse effects on fish population viability. Further, the effects of other Federal actions, including fisheries harvest management plan implementation and dam deconstruction and mitigation activities, were previously authorized for effects on listed fish, and as such, have been included in the environmental baseline. All of these actions have undergone section 7 consultations and were found to meet the ESA standards for avoiding jeopardy.

2.4. Effects of the Action on the Species and its Designated Critical Habitat

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

In this section, we evaluate the expected impacts of the proposed action on listed salmon, steelhead and eulachon in the action area. To complete the evaluation, we will:

1) Describe the general categories of effects (risks and benefits) that hatchery programs can pose to natural-origin salmon, steelhead and other fish populations (Section 2.6.1), and identify those effects associated with the proposed actions that could potentially adversely affect listed Elwha River Chinook salmon, steelhead, and eulachon in the action area.

2) Analyze the impacts on individual listed salmon, steelhead, and eulachon in the action area potentially associated with each of the proposed hatchery programs, under the effects identified in step 1, above – noting that the effect that each general risk or benefit has on natural-origin and listed hatchery-origin fish (e.g., for risks, from "no impact" to "adversely impact") will depend on the program, the program's location, species propagated, adult broodstock collection methods, juvenile fish rearing and release practices, and other factors (Section 2.6.1.1).

2.4.1. Factors to be considered

The five hatchery programs evaluated in this opinion are proposed as means to preserve, and assist in the recolonization of, native salmon and steelhead populations remaining in the Elwha River during and for a period after the removal of Elwha and Glines Canyon dams. The success of the programs in meeting these objectives is critically important. The remnant natural-origin components of all of the genetically unique populations proposed for supportive breeding have been driven to near extinction levels after 100 years of dam-related effects, with the numbers of Chinook, fall chum, and pink salmon and steelhead in the critically low 100 to 200 annual adult return abundance range. Previous authorizations have already approved the dam deconstruction project and several relevant actions, such as Chambers steelhead harvest and operation of the screw trap. The effects of dam removal and the initial vision for supportive breeding are part of the environmental baseline. This section analyzes the effects of the proposed action, comprehensive implementation of the hatchery programs in support of phase one and phase two of fish restoration in the Elwha River.

The proposed responsive hatchery actions may result in the direct and/or incidental take of listed Elwha River Chinook salmon and steelhead, and the incidental take of listed eulachon. The applicants have proposed protective measures that will minimize the extent of this take. The analysis in section 2.6.1.1 considers whether or not the five hatchery programs pose substantial risk to the likelihood of the continued survival and recovery of the listed Puget Sound Chinook salmon ESU, Puget Sound steelhead DPS and southern DPS of eulachon or adversely modify their critical habitat. Before that analysis, the remainder of this section generally describes how various aspects of hatchery programs can impact naturally produced fish populations, and what the likely potential effects of those impacts are on individuals, populations, and species.

To assist in preparing and understanding biological opnions, NMFS has recently completed a refined description of general types of effects of hatchery operations and hatchery production on salmon and steelhead population viability (NMFS 2012b). The document updates previous descriptions of hatchery-related effects included in prior NMFS hatchery consultations (NMFS 1995; NMFS 1999a; NMFS 2002b; NMFS 2002c; NMFS 2003a). In addition to incorporating findings from recent studies of hatchery-related ecological, genetic and demographic effects (e.g., Kostow 2008; Araki et al. 2008; McClure et al. 2008; Galbreath et al. 2008; Naish et al. 2008 and other references therein), the updated effects description document draws from several programmatic reviews addressing salmonid hatchery programs in the Pacific Northwest: Upstream: Salmon and Society in the Pacific Northwest (NRC 1996); Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem (ISG 1996); Review of Salmonid Artificial Production in the Columbia River Basin: As a Scientific Basis for Columbia River Production Programs (ISAB 1998); Artificial Production Review - Report and Recommendations of the Northwest Power Planning Council (NPPC 1999); A Conceptual Framework for conservation Hatchery Strategies for Pacific Salmonids (Flagg and Nash 1999); Hatchery Reform: Principles and Recommendations (HSRG 2004a); Propagated Fish in Resource Management (AFS 2005); SCA (NMFS 2008a); and A Framework for Determining Hatchery Effects (NMFS 2007a). Although this document is a valuable reference, the science on hatchery effects and approaches to analyzing them are evolving too quickly to be completely captured in periodic updates of the document. This document should by no means be considered a comprehensive treatment of the best available science releated to hatchery effects. The general effects categories and subcategories from NMFS (2012b) that may be associated with anadromous salmonid hatchery facilities and hatchery production are described in Table 13.

From the general hatchery facility and hatchery production effects identified in Table 13, NMFS has determined that the effects on listed fish species of the proposed hatchery programs considered in this opinion would be limited to a specific number of categories and subcategories (Table 14). This determination was based on the description of the hatchery programs provided in the five HGMPs, information provided in the scientific framework guiding fish restoration in the Elwha River watershed (Ward et al. 2008), general information regarding the potential effects of hatchery programs in NMFS (2012b), specific information regarding potential effects of artificial propagation on Elwha River salmon and steelhead populations (Ward et al. 2008; HSRG 2001; HSRG 2002b; HSRG 2004; HSRG 2012; NMFS 2012b) and other information as noted in the specific effects analysis sections.

Based on consideration of the above described materials, NMFS has determined that within the action area of the proposed hatchery programs, ESA-listed Chinook salmon, steelhead and eulachon have the potential to be adversely affected: (1) demographically through hatchery facility operation; broodstock collection, sampling, and transport; and through hatchery-related monitoring and evaluation activities; (2) genetically (for Chinook salmon and steelhead) through broodstock collection, selection, and mating practices, artificial propagation practices, and adult hatchery fish spawning in natural production areas; and, (3) ecologically through interactions between hatchery-origin juveniles and natural-origin fish, leading to competition and predation effects (Table 14).

The specific hatchery-related hazards identified in Table 14 that are likely to pose risks to listed fish in the action area will be more fully described, and their potential roles with respect to the proposed actions analyzed, in the next section. Programs for which specific hatchery-related hazards resulting from implementation of a specific program that were previously evaluated in separate NMFS consultations (and are included in the baseline), pose no risks, or are unlikely to pose measurable risks to listed fish are also identified. In these instances, risks to listed fish would have been previously authorized under the ESA, not be expected to occur, or would not be measurable. For these reasons, these hatchery-related hazards will not be more fully described in the following section and will not be discussed further in this opinion.

In its general hatchery effects document, NMFS acknowledges that in evaluating hatchery actions, benefits as well as risks need to be considered. A benefits section does not appear in NMFS (2012), although it is NMFS's intention to include one in the next version of the document. For this opinion, general benefits that may accrue to natural fish populations from hatchery programs are described (Table 15), derived from past NMFS biological opinion and evaluation documents (e.g., NMFS 2002a; 2003), programmatic review documents (NMFS 2004b), and considering natural population viability parameter benefits of hatchery programs defined in the NMFS Hatchery Listing Policy (70 FR 37204, June 28, 2005).

Of the general categories of potential hatchery-related benefits of hatchery production on listed species described in NMFS (2012b), NMFS reviewed the categories of potential effects of hatchery facilities on listed species and determined that benefits conferred by each Elwha River basin hatchery program to listed species would depend on the species under propagation, facilities used for fish production, and artificial propagation actions applied (Table 16). Benefit determinations are based on the description of the hatchery programs provided in the HGMPs, information included in the scientific framework for fish restoration in the Elwha River watershed (Ward et al. 2008); considerations regarding species and life stages produced in each hatchery program; known ecological relationships between salmonid species (SIWG 1984; Flagg et al. 2000); current habitat conditions, effects of dam removal on those conditions, and the likely pace of recovery of properly functioning habitat conditions in the Elwha River watershed (all from DOI et al. 1996; Pess et al. 2008; Ward et al. 2008; and Duda et al. 2008; 2011); and, other information as noted in the specific effects analysis sections.

Table 13. General categories and subcategories of potential risks posed by hatchery operations and hatchery production (NMFS 2012b).

Risk Category	Risk Subcategory	Risk Description
Facility Effects		***Impacts from existence and basic operation of hatchery***
	General facility failure	Impacts on listed fish in the hatchery and fish in wild by electrical failure, flooding, fire, etc.
	Water intake	Impacts on the environment from water withdrawal and to fish in stream from screening/impingement
	Effluent	Impacts on the environment from water quality changes, and disease incidence caused by effluent
	Structures	Impacts on the physical stream environment from physical existence of hatchery structures (e.g., gravel buildup from weirs) and fish movement blockages caused by structures
Fish removal Effects		***Impacts on the target population and non-target population(s) caused by removal of fish for culture (usually will be adults but could be juveniles or eggs)***
	Collection	Injury and death to target and non-target individuals caused by collection (will include different collection methodologies such as mainstem and off-channel weirs, seining, redd pumping)
	Demographic	Risk posed to natural-origin component from decreasing numbers due to taking fish into hatchery
Genetic Effects		***Losses of fitness and decreases in diversity caused by genetic mechanisms***
	Loss of Within-Population Diversity	Diversity/fitness loss caused by genetic drift, non-representative sampling, and inbreeding depression
	Outbreeding Effects	Fitness/diversity change caused by gene flow from other populations (outbreeding depression and loss of among-population diversity)
	Hatchery-Induced Selection	Fitness loss and phenotypic change caused by differences between the hatchery and natural environment (includes intentional selection and relaxation of selection), and sampling “errors” during fish culture
Ecological interactions		***Impacts on naturally produced fish populations resulting from hatchery-origin fish interactions in natural spawning, rearing and migration areas after the hatchery fish are released.***
	Disease	Disease risk to target and non-target populations from commingling with hatchery fish carrying fish disease pathogens.
	Competition	Impacts on target and non-target population abundance and productivity from competition for limited resources caused by released hatchery fish (includes competition due to residualism)
	Predation	Impacts on target and non-target population abundance and productivity from predation by released hatchery fish (includes predation due to residualism).
Harvest Effects		*Reductions in the total abundance of target and non-target listed fish populations due to direct or incidental harvest in fisheries.*
Monitoring & Evaluation Effects		*Demographic and program management affects associated with program performance and effects monitoring and evaluation.*
	Marking/masking	Loss of monitoring precision due to inadequate marking rate and type
	Methodology	Injury and death caused by monitoring activities
	Adequacy	Risk of undetected impacts from low power or not monitoring all areas necessary (including inadequate equipment)
	Adaptive management	Decreased ability to respond in timely manner to new information on effectiveness of programs

Table 14. Risk categories and subcategories and a description of whether these risks should be considered when evaluating the effects of the proposed Elwha River hatchery programs on listed species in the action area.

Category	Subcategory	Elwha Channel Chinook salmon	Lower Elwha Hatchery Native Steelhead	Lower Elwha Hatchery Coho Salmon	Lower Elwha Hatchery Fall Chum Salmon	Lower Elwha Hatchery Pink Salmon
Facility Effects	General facility failure	Progeny of listed natural- and hatchery-fish are reared as part of this program with potential risks to propagated fish under this risk subcategory.	Progeny of listed natural- and hatchery-fish are reared as part of this program with potential risks to propagated fish under this risk subcategory.	No listed fish are reared as part of this program and there are no risks to listed fish under this risk subcategory.	No listed fish are reared as part of this program and there are no risks to listed fish under this risk subcategory.	No listed fish are reared as part of this program and there are no risks to listed fish under this risk subcategory.
	Water intakes	Surface water intake effects on listed fish for water supplied to Elwha Channel hatchery were previously evaluated and authorized under separate consultations (NMFS 2006a; 2010; 2012a). The surface water intake at Morse Creek Hatchery has the potential to affect listed fish. The Hurd Creek (groundwater supply) and Sol Duc (no listed salmonids in watershed) hatchery components of the program will not affect listed fish under this risk category.	Surface water intake effects on listed fish for water supplied to Lower Elwha Fish Hatchery were previously evaluated and authorized under separate consultations (NMFS 2006a; 2010; 2012a).	Surface water intake effects on listed fish for water supplied to Lower Elwha Fish Hatchery were previously evaluated and authorized under separate consultations (NMFS 2006a; 2010; 2012a).	Surface water intake effects on listed fish for water supplied to Lower Elwha Fish Hatchery were previously evaluated and authorized under separate consultations (NMFS 2006a; 2010; 2012a).	Surface water intake effects on listed fish for water supplied to Lower Elwha Fish Hatchery were previously evaluated and authorized under separate consultations (NMFS 2006a; 2010; 2012a).
	Effluent	There are no substantial effluent discharge risks to listed fish resulting from this program. All component facilities operate under NPDES permits # WAG13-1043 (Elwha Channel), #	There are no substantial effluent discharge risks to listed fish resulting from this program. It operates under NPDES permit #WA-G13-0023 issued by EPA and is in compliance with effluent discharge	There are no substantial effluent discharge risks to listed fish resulting from this program. It operates under NPDES permit #WA-G13-0023 issued by EPA and is in compliance with effluent discharge	There are no substantial effluent discharge risks to listed fish resulting from this program. It operates under NPDES permit #WA-G13-0023 issued by EPA and is in compliance with effluent discharge	There are no substantial effluent discharge risks to listed fish resulting from this program. It operates under NPDES permit #WA-G13-0023 issued by EPA and is in compliance with effluent discharge

Category	Subcategory	Elwha Channel Chinook salmon	Lower Elwha Hatchery Native Steelhead	Lower Elwha Hatchery Coho Salmon	Lower Elwha Hatchery Fall Chum Salmon	Lower Elwha Hatchery Pink Salmon
		WAG13-1045 (Sol Duc), and #WAG 13-1013 (Morse Creek) issued by WDOE or produce fish at a de minim us level, and below concern regarding water quality effects (Hurd Creek). All facilities are therefore in compliance with effluent discharge requirements indicating that the program is adequately protective of downstream aquatic life, including listed fish.	requirements indicating that the program is adequately protective of downstream aquatic life, including listed fish.	requirements indicating that the program is adequately protective of downstream aquatic life, including listed fish.	requirements indicating that the program is adequately protective of downstream aquatic life, including listed fish.	requirements indicating that the program is adequately protective of downstream aquatic life, including listed fish.
	Structures	There are no effects under this subcategory as there are no hatchery-related structures associated with the program that will affect listed fish migration, rearing, or their critical habitat.	There are no effects under this subcategory as there are no hatchery-related structures associated with the program that will affect listed fish migration, rearing, or their critical habitat.	There are no effects under this subcategory as there are no hatchery-related structures associated with the program that will affect listed fish migration, rearing, or their critical habitat.	There are no effects under this subcategory as there are no hatchery-related structures associated with the program that will affect listed fish migration, rearing, or their critical habitat.	There are no effects under this subcategory as there are no hatchery-related structures associated with the program that will affect listed fish migration, rearing, or their critical habitat.
Fish Removal Effects	Collection	Effects of weirs and other methods used to collect listed Chinook salmon as broodstock, and to collect Chinook salmon for transport upstream for release were previously evaluated and authorized through separate NMFS consultations (NMFS 2006a; 2010b; 2012a). These authorizations also allowed incidental collection, handling, and	Effects of weirs and other methods used to collect listed steelhead as broodstock, and to collect steelhead for transport upstream for release were previously evaluated and authorized through separate NMFS consultations (NMFS 2006a; 2010b; 2012a).	Incidental effects of weirs and other methods used to collect coho salmon as broodstock, and to collect incidentally captured Chinook salmon and steelhead for use as hatchery broodstock or for upstream transport for release were previously evaluated and authorized through separate NMFS consultations (NMFS 2006a; 2010b; 2012a).	Incidental effects of weirs and other methods used to collect fall chum salmon as broodstock, and to collect incidentally captured Chinook salmon and steelhead for use as hatchery broodstock or for upstream transport for release were previously evaluated and authorized through separate NMFS consultations (NMFS 2006a; 2010b; 2012a).	Incidental effects of weirs and other methods used to collect pink salmon as broodstock, and to collect incidentally captured Chinook salmon and steelhead for use as hatchery broodstock or for upstream transport for release were previously evaluated and authorized through separate NMFS consultations (NMFS 2006a; 2010b; 2012a).

Category	Subcategory	Elwha Channel Chinook salmon	Lower Elwha Hatchery Native Steelhead	Lower Elwha Hatchery Coho Salmon	Lower Elwha Hatchery Fall Chum Salmon	Lower Elwha Hatchery Pink Salmon
		transport of listed steelhead.				
	Demographic	Demographic effects on listed Chinook salmon associated with broodstock collection were previously evaluated and authorized through separate NMFS consultations (NMFS 2006a; 2012a).	Demographic effects on listed steelhead associated with broodstock collection are previously authorized through separate NMFS consultations (NMFS 2006a; 2012a).	There are no demographic effects on listed fish from the collection of broodstock for this program, because adult coho salmon are the target species and no listed fish are removed.	There are no demographic effects on listed fish resulting from the collection of broodstock for this program, because adult fall chum salmon are the target species and no listed fish are removed.	There are no demographic effects on listed fish resulting from the collection of broodstock for this program, because adult pink salmon are the target species and no listed fish are removed.
Genetic Effects	Loss of Within-Population Diversity	This program may adversely affect listed Chinook salmon under this subcategory.	This program may adversely affect listed steelhead under this subcategory.	Listed fish are not propagated through this program and it would have no effect on listed fish under this subcategory.	Listed fish are not propagated through this program and it would have no effect on listed fish under this subcategory.	Listed fish are not propagated through this program and it would have no effect on listed fish under this subcategory.
	Outbreeding Depression	Only native stock Chinook salmon are propagated through the program and there will be no effect on Elwha Chinook salmon among population diversity resulting from its implementation.	Only native stock winter-run steelhead are propagated through the program and there will be no effect on Elwha River steelhead among population diversity resulting from its implementation.	Listed fish are not propagated through this program and it would have no effect on listed fish under this subcategory.	Listed fish are not propagated through this program and it would have no effect on listed fish under this subcategory.	Listed fish are not propagated through this program and it would have no effect on listed fish under this subcategory.
	Hatchery-Induced Selection	This program may adversely affect listed Chinook salmon under this subcategory.	This program may adversely affect listed steelhead under this subcategory.	Listed fish are not propagated through this program and it would have no effect on listed fish under this subcategory.	Listed fish are not propagated through this program and it would have no effect on listed fish under this subcategory.	Listed fish are not propagated through this program and it would have no effect on listed fish under this subcategory.
Ecological Interaction Effects	Disease	The program is unlikely to substantially affect listed fish through fish disease pathogen amplification and transfer. All Puget Sound region hatcheries are managed in accordance with the	The program is unlikely to substantially affect listed fish through fish disease pathogen amplification and transfer. All Puget Sound region hatcheries are managed in accordance with the "Salmonid	The program is unlikely to substantially affect listed fish through fish disease pathogen amplification and transfer. All Puget Sound region hatcheries are managed in accordance with the "Salmonid Disease	The program is unlikely to substantially affect listed fish through fish disease pathogen amplification and transfer. All Puget Sound region hatcheries are managed in accordance with the "Salmonid Disease	The program is unlikely to substantially affect listed fish through fish disease pathogen amplification and transfer. All Puget Sound region hatcheries are managed in accordance with the "Salmonid Disease

Category	Subcategory	Elwha Channel Chinook salmon	Lower Elwha Hatchery Native Steelhead	Lower Elwha Hatchery Coho Salmon	Lower Elwha Hatchery Fall Chum Salmon	Lower Elwha Hatchery Pink Salmon
		"Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State (NWIFC and WDFW 2006) to reduce risks of fish disease risks to propagated and natural fish populations through regular fish health monitoring and reporting, and application of measures to reduce fish health risks.	Disease Control Policy of the Fisheries Co-managers of Washington State (NWIFC and WDFW 2006) to reduce risks of fish disease risks to propagated and natural fish populations through regular fish health monitoring and reporting, and application of measures to reduce fish health risks.	Control Policy of the Fisheries Co-managers of Washington State (NWIFC and WDFW 2006) to reduce risks of fish disease risks to propagated and natural fish populations through regular fish health monitoring and reporting, and application of measures to reduce fish health risks.	Control Policy of the Fisheries Co-managers of Washington State (NWIFC and WDFW 2006) to reduce risks of fish disease risks to propagated and natural fish populations through regular fish health monitoring and reporting, and application of measures to reduce fish health risks.	Control Policy of the Fisheries Co-managers of Washington State (NWIFC and WDFW 2006) to reduce risks of fish disease risks to propagated and natural fish populations through regular fish health monitoring and reporting, and application of measures to reduce fish health risks.
	Competition	Competition may occur between listed hatchery-origin juvenile and adult Chinook salmon produced by the program and listed natural-origin Chinook salmon of the same life stages.	Competition may occur between listed hatchery-origin juvenile and adult steelhead produced by the program and listed natural-origin steelhead of the same life stages.	Competition may occur between hatchery-origin juvenile and adult coho salmon produced by the program and listed fish of the same life stages in areas where the species interact.	Adult chum salmon produced by the program may compete with listed steelhead for spawning space, but the fry migrant life history for chum salmon and diet preference differences between the species makes competition with listed juvenile fish unlikely.	Adult pink salmon produced by the program may compete with listed Chinook salmon for spawning space, but the fry migrant life history for pink salmon and diet preference differences between the species makes competition with listed juvenile fish unlikely.
	Predation	Predation by hatchery-origin Chinook salmon juveniles on listed juvenile fish may occur.	Predation by hatchery-origin steelhead smolts on listed juvenile fish may occur.	Predation by hatchery-origin coho salmon smolts on listed juvenile fish may occur.	Predation by hatchery-origin chum salmon fry on listed juvenile fish is unlikely because of the relatively small individual size of hatchery chum salmon at release and planktonic diet preference of the species.	Predation by hatchery-origin pink salmon fry on listed juvenile fish is unlikely because of the relatively small individual size of hatchery pink salmon at release and planktonic diet preference of the species.
Harvest Effects		Harvest impacts associated with hatchery Chinook salmon production on listed Chinook salmon have	Incidental effects during the preservation phase have been evaluated and authorized previously in a separate NMFS	Harvest impacts associated with hatchery coho production on listed Chinook salmon have been evaluated and authorized	This program is unlikely to lead to harvest effects on listed fish because no fisheries targeting this species will result from	This program is unlikely to lead to harvest effects on listed fish because no fisheries targeting this species will result from

Category	Subcategory	Elwha Channel Chinook salmon	Lower Elwha Hatchery Native Steelhead	Lower Elwha Hatchery Coho Salmon	Lower Elwha Hatchery Fall Chum Salmon	Lower Elwha Hatchery Pink Salmon
		been evaluated and authorized previously in a separate NMFS consultation (NMFS 2011b).	consultation (NMFS 2011b). Effects of proposed native stock hatchery-origin steelhead-directed fisheries (LEKT 2012d) will be evaluated by NMFS through a separate ESA consultation process.	previously in a separate NMFS consultation (NMFS 2011b).	implementation of the proposed program.	implementation of the proposed program.
Monitoring & Evaluation Effects	Marking /masking	The risk of this hazard is adequately minimized because all hatcheries Chinook salmon will be internally or externally marked to differentiate them from natural-origin fish for program performance and effects monitoring purposes.	The risk of this hazard is adequately minimized because all hatchery steelhead will be internally or externally marked to differentiate them from natural-origin fish for program performance and effects monitoring purposes.	The risk of this hazard is adequately minimized because all hatchery coho salmon will be internally or externally marked to differentiate them from natural-origin fish for program performance and effects monitoring purposes.	The risk of this hazard is adequately minimized because all hatchery fall chum salmon will be internally or externally marked to differentiate them from natural-origin fish for program performance and effects monitoring purposes.	The risk of this hazard is adequately minimized because all hatchery pink salmon will be internally or externally marked to differentiate them from natural-origin fish for program performance and effects monitoring purposes.
	Methodology	Proposed monitoring and evaluation actions may cause injury or death to listed fish.	Proposed monitoring and evaluation actions may cause injury or death to listed fish.	Proposed monitoring and evaluation actions may cause injury or death to listed fish.	Proposed monitoring and evaluation actions may cause injury or death to listed fish.	Proposed monitoring and evaluation actions may cause injury or death to listed fish.
	Adequacy	Proposed monitoring and evaluation actions are adequate to measure risks to listed fish.	Proposed monitoring and evaluation actions adequate to measure risks to listed fish.	Proposed monitoring and evaluation actions adequate to measure risks to listed fish.	Proposed monitoring and evaluation actions adequate to measure risks to listed fish.	Proposed monitoring and evaluation actions adequate to measure risks to listed fish.
	Adaptive management	Proposed monitoring and evaluation actions and reporting would be completed in a timely manner to allow evaluation of program impacts on listed fish and implementation of adaptive actions to reduce identified risks as necessary.	Proposed monitoring and evaluation actions and reporting would be completed in a timely manner to allow evaluation of program impacts on listed fish and implementation of adaptive actions to reduce identified risks as necessary.	Proposed monitoring and evaluation actions and reporting would be completed in a timely manner to allow evaluation of program impacts on listed fish and implementation of adaptive actions to reduce identified risks as necessary.	Proposed monitoring and evaluation actions and reporting would be completed in a timely manner to allow evaluation of program impacts on listed fish and implementation of adaptive actions to reduce identified risks as necessary.	Proposed monitoring and evaluation actions and reporting would be completed in a timely manner to allow evaluation of program impacts on listed fish and implementation of adaptive actions to reduce identified risks as necessary.

Table 15. General categories of potential benefits to listed species associated with hatchery operations and hatchery production.

Benefit Category	Benefit Subcategory	Benefit Description
Population Viability Effects		***Direct and indirect beneficial effects on listed fish population viability associated with the production of juvenile and adult hatchery-origin fish.***
	Abundance	Preservation of, or increases in gametes, the number of natural spawners, juvenile progeny, or the abundance of a natural-origin fish.
	Diversity	Preservation of genetic resources, including different life-history types and run timing.
	Spatial Structure	Preservation of extant spatial structure, reintroduction into inaccessible areas, and acceleration of recolonization of previously occupied habitats and former range.
	Productivity	The only potential benefit is when fish otherwise cannot find a mate.
Marine-Derived Nutrient Effects	-	Abundance and/or productivity increases in listed fish populations resulting from the inland distribution of marine-derived nutrients from hatchery carcasses.
Spawning Sediments		Fine sediments are removed from spawning substrates by spawning hatchery fish.

Table 16. Benefit categories and subcategories for listed species and a description of whether these benefits should be considered when evaluating the effects of the proposed Elwha River hatchery programs on listed species in the action area.

Category	Subcategory	Elwha Channel Chinook salmon	Lower Elwha Hatchery Native Steelhead	Lower Elwha Hatchery Coho Salmon	Lower Elwha Hatchery Fall Chum Salmon	Lower Elwha Hatchery Pink Salmon
Population Viability Effects	Abundance	The program may benefit listed Chinook salmon abundance	The program may benefit listed steelhead abundance	The program is unlikely to benefit listed fish abundance	The program is unlikely to benefit listed fish abundance	The program is unlikely to benefit listed fish abundance
	Diversity	The program may benefit listed Chinook salmon diversity	The program may benefit listed steelhead diversity	The program is unlikely to benefit listed fish diversity	The program is unlikely to benefit listed fish diversity	The program is unlikely to benefit listed fish diversity
	Spatial Structure	The program may benefit listed Chinook salmon spatial structure	The program may benefit listed steelhead spatial structure	The program is unlikely to benefit listed fish spatial structure	The program is unlikely to benefit listed fish spatial structure	The program is unlikely to benefit listed fish spatial structure
	Productivity	Because the population is at a critical abundance level, the program may benefit listed Chinook salmon productivity	Because the population is at a critical abundance level, the program may benefit listed steelhead productivity	The program is unlikely to benefit listed fish productivity	The program is unlikely to benefit listed fish productivity	The program is unlikely to benefit listed fish productivity
Marine-Derived Nutrient Effects	Marine-derived nutrients from returning hatchery adults are expected to benefit listed fish populations.	Marine-derived nutrients from returning hatchery Chinook salmon adults may benefit listed Chinook salmon and steelhead.	Marine-derived nutrients from returning hatchery steelhead adults may benefit listed Chinook salmon and steelhead.	Marine-derived nutrients from returning hatchery coho adults may benefit listed Chinook salmon and steelhead.	Marine-derived nutrients from returning hatchery fall chum adults may benefit listed Chinook salmon and steelhead.	Marine-derived nutrients from returning hatchery pink salmon adults may benefit listed Chinook salmon and steelhead.

In weighing the benefits and risks in Table 14 and Table 16, NMFS has determined that ESA-listed Elwha River Chinook salmon and steelhead are likely to benefit from implementation of the proposed actions. Chinook salmon and steelhead are likely to benefit: (1) demographically through supportive breeding and resultant preservation of the species during and for a period following dam removal when conditions are inhospitable to natural fish survival and as critical habitat in the lower river and estuary recovers; and by providing adult returns to natural spawning areas in lower river and newly accessible upriver habitat to augment natural-origin fish abundances; (2) genetically through supportive breeding and preservation of remaining genetic diversity that currently resides substantially in the hatchery Chinook salmon population in particular; (3) spatially through preservation of extant population distribution in accessible critical habitat during and for a period following dam removal, and through production and upstream transport of adults and juvenile fish produced through the programs into pristine upriver habitat before and as migration access to the area is restored; (4) ecologically through increases in the level of marine derived nutrients conferred by naturally spawning hatchery-origin fish reaching upriver areas that have been previously starved of such nutrients by dam blockage of anadromous fish access, and through increases in juvenile fish prey for rearing and migrating juvenile listed fish; (5) from the removal of Chambers Creek steelhead that pose a threat to steelhead viability; and (6) in productivity because the populations at are extremely low abundance and spawners may have trouble finding mates in the absence of hatchery supplementation. Benefits and risksfor each program will be more fully described, and their potential roles with respect to the proposed actions analyzed, in the next section. Categories identified in Table 16 as unlikely to benefit, or not benefitting, from a particular hatchery program will not be discussed further in this opinion for the reasons summarized in the table.

2.4.2. Effects of Hatchery Programs

2.4.2.1. Risks

The specific risks to listed Chinook salmon, steelhead, and eulachon in the action area that may result from implementation of the proposed actions described in Section 1.3 of this opinion are evaluated below. Subcategories of risks identified in Table 14 as potentially occurring associated with a particular hatchery program are considered. Hatchery programs for which there are no effects, or for which effects are identified in Table 14 as not likely to be measureable, are not further evaluated.

2.4.2.1.1. *Facility Effects - General Facility Failure*

Disruption of critical components of the hatchery physical plant and infrastructure, including failure of water delivery systems, impacts from natural flooding events, fire, vandalism, and poor fish culture practices may lead to the catastrophic loss of fish under propagation. This risk is of particular concern when proposed programs rear listed fish species. For such hatchery programs, NMFS must make a determination whether the facility and its operations adequately ensure the safety and survival of the listed species under propagation. General hatchery facility risks to listed hatchery fish populations must be minimized through implementation of certain risk reduction measures (see NMFS 2012b). To determine whether a proposed program that propagates listed fish poses substantial risks under this hazard category, NMFS reviews sections 4 ("Water Source") and 5 ("Facilities") of proposed HGMPs, and any additional risk reduction measures identified in subsequent HGMP sections addressing artificial propagation practices, to gauge the adequacy of the hatchery facility and the program operational infrastructure for safeguarding listed fish while under propagation. NMFS also conducts site visits to affirm that the subject hatchery facilities are adequate for listed fish propagation and attainment of hatchery facility failure risk reduction objectives.

2.4.2.1.2. *Elwha Channel Hatchery Program*

The Elwha Channel Hatchery program is unlikely to pose substantial risks of general facility failure to listed Chinook salmon, steelhead, or eulachon. Hatchery-origin Elwha Chinook salmon are included as part of the listed Puget Sound Chinook salmon ESU, so potential effects of general facility failure are of concern. The facilities included in this program (Elwha Channel, Hurd Creek, Sol Duc, and Morse Creek hatcheries) have sufficient built-in and operational safeguards in place to adequately reduce the risk of catastrophic loss of the listed hatchery Chinook salmon held as adults and reared as juveniles. Water supplies at the hatcheries have all necessary water withdrawal permits (Section 1.3.1), and are located and operated to ensure consistent delivery of required volumes of high quality water are continuously supplied for maintaining healthy Chinook salmon at proposed annual production levels (WDFW 2012). All of the operations have back-up gravity fed water supplies and/or generators that would provide water to rearing Chinook salmon in the event of failure of main water delivery systems. Each of the hatchery sites is attended by trained hatchery staff, providing 7day per week, 24 hour per day capability for promptly responding in a timely manner to risks to listed fish from power failure, fire, flooding, and vandalism. All WDFW hatchery personnel are trained in standard fish propagation and fish health maintenance methods to help ensure that Chinook salmon under propagation are adequately protected from catastrophic loss due to poor hatchery practices, adverse water quality conditions, or fish health issues associate with poor water quality or inadequate quantity. Annual survival rates by hatchery life stage reported in the WDFW HGMP for the Elwha Channel Hatchery program (WDFW 2012) are within or above goal rates reported for Puget Sound hatcheries in Fuss and Ashcraft (1995), indicating that the facility is being operated in a manner that adequately safeguards Chinook salmon under propagation.

2.4.2.1.3. *Lower Elwha Fish Hatchery Native Steelhead Program*

The Lower Elwha Fish Hatchery Native Steelhead program is unlikely to pose substantial risks of general facility failure to the health or survival of listed steelhead, Chinook salmon, or eulachon. The native winter-run steelhead propagated through the program are part of the listed Puget Sound steelhead DPS. Lower Elwha Fish Hatchery, where all artificial propagation activities for the listed population take place, is a new facility with state-of-the-art water delivery and rearing structures designed to reduce the risk of catastrophic fish loss due to facility failure (LEKT 2012a). Located adjacent to the right bank of a lower Elwha River side-channel, the hatchery site is protected from flooding by the Federal Lower Elwha Flood Control Levee. The hatchery site is located on the eastside of the current southern terminus of the levee, and all hatchery water delivery and rearing structures are protected. The water supplies for the facility are permitted by appropriate federal and state agencies, and include both surface and groundwater sources (Section 1.3.2 of this opinion; LEKT 2012a). Redundancy of water sources and a power generator maintained on site adequately minimize the risk of catastrophic fish loss through water supply failure to rearing steelhead. Hatchery staff reside on-site and the facility is attended 7 days per week and 24 hours per day to ensure proper operation. In addition, the facility has power loss and low water alarm systems to alert staff to facility failures, allowing prompt response to emergencies that would threaten fish under propagation. Key tribal hatchery personnel are trained in fish propagation and fish health maintenance methods to help ensure that steelhead under propagation are adequately protected from catastrophic loss due to poor hatchery practices, adverse water quality conditions, or fish health issues associate with poor water quality or inadequate quantity.

For the above reasons, NMFS has determined that the risks to Chinook salmon, steelhead, and eulachon of general facility failure through the programs that rear these listed fish species are unsubstantial. Risks are adequately addressed by hatchery design and hatchery operation implementation measures that would be applied to propagate the listed Chinook salmon and steelhead through the Elwha Channel Hatchery and Lower Elwha Fish Hatchery programs. None of the other hatchery programs would propagate listed salmon or steelhead, and would therefore pose no general facility failure risks to listed Elwha River Chinook salmon or steelhead.

2.4.2.1.3.1. Facility Effects - Hatchery Water Intake

Water withdrawals for hatcheries within natural spawning and rearing areas can diminish stream flow, impede migration, and affect the spawning behavior of listed fish. Water withdrawals may also affect other stream-dwelling organisms that serve as food for juvenile salmonids by reducing the amount or quality habitat and through displacement and physical injury. Hatchery intakes must be screened to prevent fish injury and mortality from impingement or entrainment (permanent removal from streams). To prevent these outcomes, water rights issued for regional hatcheries are conditioned to prevent salmon migration, rearing, or spawning areas from becoming de-watered. Hatcheries can also be designed to be non-consumptive. Water used in the facility can be returned near the point where it was withdrawn so that effects on flow levels in the surface source are *de minim is*, and flow-related effects on naturally produced fish and other aquatic fauna are unsubstantial. The risks associated with water withdrawals can generally be adequately minimized by complying with water right permits and meeting NMFS screening criteria (NMFS 2008a). NMFS screening criteria for water withdrawal devices set forth conservative standards that help minimize the risk of harming naturally produced salmonids and other aquatic fauna. These risks can also be reduced or eliminated through the use of well water sources for the operation of all or portion of the facility production (NMFS 2012b).

Elwha Channel Hatchery Program

Chinook salmon rearing at the four facilities used for fish production is supported by a mix of surface and groundwater sources. Elwha Channel Hatchery relies predominantly on surface water supplied from the water diversion facility located at RM 3.2 on the mainstem Elwha River. Listed fish population effects of water withdrawal and screening from this surface water source were previously evaluated and authorized by NMFS through separate ESA consultations (NMFS 2006a; 2010b; 2012a). In 2012, unanticipated, excessive debris flows from mobilized sediments stored behind the dams caused the operators of the surface water diversion facility supplying water for the hatcheries to periodically remove and clean the screens on the facility. This measure was necessary to to prevent complete loss of water to the hatcheries, and to the City of Port Angeles, from screen blockage from debris. The effects of this periodic screen removal on listed fish in the river through entrainment are unknown. However, because few natural fish are likely present in the lower river location of the screening facility under current inhospitable turbidity and sediment transport conditions, and considering the screens were removed for a short duration, effects on listed fish were likely unsubstantial. Effects of surface water withdrawal on listed fish associated with the Elwha Channel Hatchery operation are incorporated into the environmental baseline for this opinion. Up to 1,200 gpm of groundwater sourced from river infiltration wells and authorized through a state water withdrawal permit would be used for adult holding, and (periodically) egg incubation and initial fish rearing at Elwha Channel Hatchery. Magirl et al. (2011) reported a strong hydraulic connection between river stage and wells adjacent to the river channel under low-flow and peak-flow conditions using groundwater data and model simulation results. Based on data from aquifer tests, the average hydraulic conductivity of the lower Elwha River aquifer is 715 feet per day, annually ranging from 195 to 1,593 feet per day (Magirl et al. 2011, citing Pacific Groundwater Group 2005). Withdrawal of groundwater for use in the hatchery would have no effect on listed fish in the Elwha River, because there are no surface screens that could affect fish. Further, the relatively low amount of water withdrawn relative to surface water supplied groundwater flow – mean annual surface water flow in the Elwha River is 1,520 ft^3/s (~608,000 gpm) - Duda et al., 2008; 2011) would not affect water quality or quality in Elwha River critical fish habitat. In addition, all water used by the hatchery would be returned to the river near the point of withdrawal, and there would be no net loss in river flow volume.

Hurd Creek Hatchery, where egg incubation occurs in support of the program, uses groundwater supplied by 5 wells at a rate of up to 2,000 gpm as the water source. The withdrawal of groundwater does not pose risks to listed fish populations in the Dungeness River, because there are no risks of fish impingement or entrainment on buried well head screens, and water withdrawal at the 2,000 gpm level does not affect water quantity or quality in critical fish habitat (water is returned to Hurd Creek near the point of groundwater withdrawal). There are no effects on listed fish under this risk category for the Sol Duc Hatchery rearing phase for the program, because there are no listed salmon and steelhead populations in the watershed. The Morse Creek Hatchery component of the Chinook salmon supportive breeding program operates using surface water collected form Morse Creek. The creek is designated critical habitat for listed Chinook salmon, and listed Elwha Chinook salmon produced by the program return to the creek as adults. Pumps in Morse Creek withdraw water at rates ranging from 1,600 to 2,400 gpm for fish rearing (WDFW 2012). Withdrawal of water from Morse Creek is approved under WDOE water right permit #S2-30527. Intake screening used to withdraw water meets NMFS screening criteria

(NMFS 2008a), and is adequately protective of listed Chinook salmon and steelhead regarding impingement and entrainment effects. The Morse Creek Hatchery water intake structure does not impede upstream and downstream fish migration, and as such, has no adverse effects on listed fish.

Lower Elwha Fish Hatchery (all programs)

Water used for fish production at the facility is obtained from surface and ground water sources. Listed fish population effects of surface water withdrawal at the RM 3.2 water diversion facility on the Elwha River for use at the hatchery were previously evaluated and authorized by NMFS through separate ESA consultations (NMFS 2006a; 2010b; 2012a). Effects of surface water withdrawal on listed fish associated with the Lower Elwha Fish Hatchery operation are incorporated into the environmental baseline for this opinion. Six wells at the facility provide up to 4,000 gpm of groundwater, augmenting the surface water source for fish rearing. There is no risk of fish impingement or entrainment on screens for this water source because the groundwater withdrawal points for the wells are buried. The appropriation of groundwater at a 4,000 gpm rate would not substantially affect primary constituent elements for listed fish critical habitat in the river, including river level and water quality, because removal of this amount of water is a very low proportion (0.7%) of the total volume surface water fed groundwater flow sustaining fish habitat in the lower Elwha River (see above cites from Magirl et al. (2011) in Elwha Channel Hatchery groundwater effects evaluation section). Also, the use of water is non-consumptive, as all water withdrawn for hatchery fish rearing at the facility is returned to the Elwha River immediately adjacent to where the water is withdrawn from the wells. Consistent with NMFS (2012b), there are therefore no measurable effects on listed fish populations under this risk category that are associated with withdrawal of groundwater for hatchery use.

For the above reasons, NMFS has determined that the effects of the operation of these facilities with respect to water withdrawals and the water intake themselves, as operated under previous NMFS authorizations (NMFS 2006a; 2010b; 2012a) and state water right permits, would not be measurable and would not impact listed juvenile or adult Chinook salmon, steelhead, or eulachon or their designated critical habitat in the Elwha River Basin. NMFS is not currently considering potential effects of any future violations of requirements under the previous NMFS consultations, or of water right permits, on listed species. NMFS considers that any such violations would trigger reinitiation of consultation.

2.4.2.1.3.2. Removal Effects - Collection

Impacts on target and non-target fish populations can occur as a result of hatchery broodstock collection activities. Impacts can vary depending on the method of collection, but may include injury, mortality, or removal from the natural spawning population. Broodstock collection methods can include: retention of adult fish recruiting volitionally to the hatchery; capture of adults using a weir positioned in river migration areas; and, capture and retention of adult fish from river holding and spawning areas using seines, gill nets or hook and line.

Of these collection methods, full river-spanning weirs/traps located in mainstem river or tributary migration areas may have the greatest impact on fish, as they effectively block upstream migration, and force adult fish encountered to enter a trap and holding area. Trapped fish are counted and either retained for use in the hatchery or released to spawn naturally. As detailed in RIST (2009), the physical presence of a weir or trap can affect salmonids by:

- Delaying upstream migration;
- Causing the fish to reject the weir or fishway structure, thus inducing spawning downstream of the trap (displaced spawning);
- Contributing to fallback, impingement on the weir face, and consequential injury or mortality of fish that have passed above the weir; and
- Injuring or killing fish when they attempt to jump the barrier or during fish confinement and holding prior to handling in trap boxes.

Impacts that may be associated with weir or trap operation include (generally from RIST 2009):

- Physically harming the fish during their capture from traps and retention;
- Harming fish by holding them for long durations;
- Physically harming fish during handling and biological sampling;
- Increasing fish susceptibility to displacement downstream and predation during the post-capture recovery period, if the fish are released; and
- Increasing fish vulnerability to predation through the migration blockage and corralling effects of the weir and trap.

Design and operation of weirs and traps can determine the degree to which fish may be adversely affected (see Hevlin and Rainey 1993; NMFS 2008a). To meter fish encounter levels, weir/trap-based collection operations can be operated in one of two modes: continuously, where up to 100 percent of the targeted fish run is collected and those fish not needed for broodstock are released upstream to spawn naturally; or, periodically, where the weir is operated for a number of days each week to collect broodstock and otherwise removed to allow unimpeded fish passage for the rest of the week. The mode of operation is established during the development of site-based broodstock collection protocols and can be adjusted based on in-season escapement estimates and environmental factors to reduce capture and handling risks to the targeted fish population. For example, the potential for weir rejection, fallback, and injury resulting from the operation of a weir or trap can be minimized by allowing unimpeded fish passage for a period each week. Trained hatchery personnel can reduce weir/trap impacts on fish during operation by removing debris, preventing poaching, and ensuring safe and proper facility operation. Delay and handling stress may also be reduced by holding fish after capture for the shortest time possible (less than 24 hours), providing for the recovery from handling and (to the extent feasible) immediate release upstream of fish that are not retained for use as broodstock and intended for natural spawning (NMFS 2006a; 2010a; 2012a).

Collection effects on target and non-target fish populations associated with placement and operation of fish ladders, weirs and traps at hatcheries are generally confined to hatchery-origin adult fish homing back to their site of release. This is especially true for collection operations at hatcheries located where natural-origin fish are not produced, such as created outlet channels for the discharge of hatchery water. Encounters with non-target natural fish are usually very low, and unsubstantial relative to total natural fish population sizes at such locations. Any effects on the target returning hatchery-origin fish and non-target fish encountered can be reduced through application of the same operational measures described above for mainstem weir/trap operations. Effects of other methods used to collect salmon and steelhead as broodstock, including seines, gill nets, and hook and line sampling, can be reduced by: maintaining fish in water at all times after capture; immediately releasing incidentally captured non-target species; holding fish retained as broodstock in areas and using equipment that maintains their health and safety (e.g., holding tubes in locations with sufficient flow); and holding broodstock fish for minimal durations prior to transfer to hatchery locations for spawning.

Hatchery broodstock collection effects on listed Chinook salmon, steelhead and eulachon in the Elwha River were previously evaluated and authorized for the five hatchery programs through separate ESA consultations for dam deconstruction project effects (NMFS 2006a; 2010; 2012a). Through these consultations, NMFS determined that broodstock collection activities for supportive breeding programs to preserve and restore remaining native salmon and steelhead populations, including operation of the mainstem weir located at RM 3.7 of the Elwha River, operation of hatchery traps at Elwha Channel Hatchery and Lower Elwha Fish Hatchery, and opportunistic capture of salmon and native steelhead using seines, gill nets, and hook and line, were not likely to jeopardize the continued existence of the Puget Sound Chinook salmon ESU and Puget Sound steelhead DPS, nor adversely modify or destroy critical habitat for Puget Sound Chinook salmon (NMFS 2006a; 2012a). A primary basis for this conclusion was that the supportive breeding and captive broodstock programs, made possible by the broodstock collection actions, will help ensure the preservation of native Elwha River Chinook salmon and steelhead through periods of high impacts on fish and habitat from dam removal that might otherwise result in the extirpation of the populations (NMFS 2012b). The listed and non-listed fish propagated through the hatchery programs have over-lapping adult return timings to the river, leading to direct or incidental collection effects on listed Chinook salmon and steelhead that are authorized through the NMFS consultations for the five hatchery programs.

Although NMFS has not yet prepared the ESA section 4(d) rule-making prohibiting take of threatened eulachon, NMFS reviewed the amount or extent of listed eulachon take effects for dam deconstruction, including effects associated with broodstock collection activities for Chinook salmon (NMFS 2010b). Through that consultation, NMFS assigned terms and conditions that would minimize the effects of any anticipated take. Collection effects associated with the Chinook salmon and native steelhead hatchery programs (WDFW 2012; LEKT 2012a), and by extension because the same types of broodstock collection methods would be used, the coho salmon, fall chum salmon, and pink salmon hatchery programs, will therefore not be evaluated further in this opinion.

2.4.2.1.3.3. Removal Effects - Demographic

Demographic effects on natural populations of salmon and steelhead may result from using fish for hatchery broodstock instead of allowing them to spawn naturally. The removal of adults from a naturally-spawning population has the potential to reduce the size of the natural population (sometimes called “mining”), cause selection effects, and remove nutrients from upstream reaches (Spence et al. 1996; NRC 1996; Kapusinski 1997). Where listed salmonid populations are not replacing themselves, supplementation hatchery programs may be implemented to slow trends toward extinction and buy time until the factors limiting population viability are corrected. In such cases, risks to the natural population, including numerical reduction and selection effects, may be subordinate to the need to expeditiously implement the artificial production programs that will reduce the likelihood of extinction in the short term of the populations and potentially the ESU (e.g., Redfish Lake sockeye).

Demographic effects on listed Chinook salmon, steelhead, and eulachon associated with broodstock collection for the Elwha Channel Hatchery Chinook salmon (WDFW 2012) and Lower Elwha Fish Hatchery native steelhead (LEKT 2012a) programs were previously evaluated and authorized through separate NMFS consultations (NMFS 2006a; 2010b; 2012a). NMFS determined that removal of returning adult Chinook salmon and steelhead for use as hatchery broodstock or for upstream transport and release as described in the HGMPs, were necessary measures to preserve native Elwha River Chinook salmon and steelhead through the periods of high impact from dam removal that might otherwise result in extirpation of the populations (NMFS 2012a). For the other three hatchery programs, there are no demographic effects on listed species associated with their implementation, as the programs are conducted for the purpose of propagating non-listed fish species, and removal of listed fish from the natural environment is not an objective. The methods used to secure coho, fall chum, and pink salmon adults as broodstock preclude incidental capture and adverse effects on eulachon. This listed forage fish species is of a relatively small individual size relative to salmon adults, and would not be susceptible to capture and handling in weirs, traps, and nets that would be used to secure much larger adult salmon of these species as broodstock.

2.4.2.1.4. *Genetic Effects*

Evaluated in this section are the effects on listed salmon and steelhead diversity resulting from implementation of the supportive breeding programs. Of concern regarding genetic effects are the two hatchery programs propagating Chinook salmon and native winter-run steelhead. Implementation of the Elwha Channel Hatchery Chinook salmon program (WDFW 2012) and the Lower Elwha Fish Hatchery native steelhead program (LEKT 2012a) pose genetic risks to the listed Elwha River Chinook salmon and steelhead populations, respectively. The hatchery programs producing coho, fall chum, and pink salmon (LEKT 2012b; 2012c; LEKT and WDFW 2012) will have no effect on the genetic diversity of listed Chinook salmon and steelhead. These latter programs propagate species that do not interbreed with Chinook salmon or steelhead, and no genetic effects on listed species will therefore result from their implementation. For these reasons, the proposed coho, fall chum, and pink salmon hatchery programs will not be further discussed in this section.

In evaluating the genetic effects of the proposed Chinook salmon and native steelhead hatchery programs, based on currently available scientific information including NMFS 2012b, NMFS believes that artificial breeding and rearing are *in general* likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to diversity and productivity levels for the reference natural populations. Hatchery practices may therefore pose a risk to Chinook salmon and steelhead population recovery when hatchery-origin fish interbreed with natural-origin fish from the same population. However, the *level* of any risk cannot be generalized, because so much depends on local conditions and circumstances including the status of the natural population(s), the condition of habitat that support the fish, the short and long-term implications and consequences for different species, for species with multiple life-history types, and for species subjected to different hatchery practices and protocols.. Generally speaking, NMFS believes the key question is, would the natural population(s) be better off with or without supportive breeding.

NMFS believes hatchery intervention is a legitimate and useful tool to help avert, at least in the short-term, salmon and steelhead population extinction. Managers should, however, seek to reduce interactions between hatchery and natural-origin fish as the risk of extinction is reduced (e.g., after the preservation and recolonization phases of fish restoration in the Elwha River). Responsive genetic risk reduction measures bearing on the effects of supportive breeding and the level of naturally spawning hatchery fish should be implemented consistent with the overall recovery of listed ESUs or DPSs.

The genetic risks that artificial propagation pose to naturally produced populations can be separated into two general categories: 1) reductions or changes in the genetic variability (diversity) among populations; and 2) and) reductions or changes in the genetic variability within populaitons (Hard et al. 1992; Cuenco et al. 1993; NRC 1996; Waples and Drake 2004). Germane to evaluations of genetic risks within these two risk categories are three types of effects: loss of within-population diversity, outbreeding effects, and hatchery-induced selection (aka “domestication”). These three types of risks are evaluated below for the proposed Chinook salmon and steelhead programs.

2.4.2.1.4.1. Loss of Within Population Diversity

Loss of within-population genetic diversity (variability) is defined as the reduction in quantity, variety, and the combinations of alleles in a population (Busack and Currens 1995). Quantity is defined as the proportion of an allele in the population and variety is the number of different kinds of alleles in the population. Genetic diversity within a population can change from random genetic drift and from inbreeding. Random genetic drift occurs because the progeny of one generation represents a sample of the quantity and variety of alleles in the parent population. Since the next generation is not an exact copy of the parent generation, rare alleles can be lost, especially in small populations where a rare allele is less likely to be represented in the next generation (Busack and Currens 1995).

The process of genetic drift is governed by the effective population size (N_e) rather than the observed number of breeders. The effective size of a population is defined as the size of an idealized population that would produce the same level of inbreeding or genetic drift seen in an observed population of interest (Halliburton 2004). Attributes of such an idealized population typically include discrete generations, equal sex ratios, random mating and specific assumptions about the variance of family size. Natural populations almost always violate one or more of these idealized attributes, and the effective size of a population is therefore almost always smaller than the observed census size. Small effective population size in hatchery programs can be caused by (from Gharrett and Shirley 1985; Simon et al. 1986; Withler 1988; Waples 1991; Campton 1995):

- Using a small number of adults for hatchery broodstock.
- Using more females than males (or males than females) for the hatchery broodstock.

- Pooling the gametes of many adults during spawning, which would allow one male to potentially dominate during fertilization.
- Changing the age structure of the spawning population from what would have occurred naturally.
- Allowing progeny of some matings to have greater survival than allowed others.

Some hatchery stocks have been found to have less genetic diversity and higher rates of genetic drift than some naturally produced populations, presumably as a result of a small effective number of breeders in the hatcheries (Waples et al. 1990). Potential negative impacts of artificial propagation on within population diversity may be expressed by changes in morphology (e.g., Bugert et al. 1992) or behavior (e.g. Berejikian 1995). Busack and Currens (1995) observed that it would be difficult to totally control random loss of within population genetic diversity in hatchery populations, but by controlling the broodstock number, sex ratios, and age structure, loss could be minimized. Theoretical work has demonstrated that hatcheries can reduce the effective size of a natural population in cases where a large number of hatchery strays are produced by a relatively small number of hatchery breeders (Ryman et al. 1995). This risk can be minimized by ensuring that hatcheries incorporate natural-origin fish as broodstock and produce large effective population sizes. The risk can also be reduced by controlling the rate of straying of hatchery fish into spawning areas used by naturally produced populations.

Inbreeding is the interbreeding of related individuals. Inbreeding per se does not lead directly to changes in the quantity and variety of alleles but can increase both individual and population homozygosity. This homozygosity can change the frequency of phenotypes in the population, which are then acted upon by the environment. If the environment is selective towards specific phenotypes then the frequency of alleles in the population can change (Busack and Currens 1995). Increased homozygosity is also often expected to lead to a reduction in fitness called inbreeding depression. Inbreeding depression occurs primarily because nearly all individuals harbor large numbers of deleterious alleles whose effects are masked because they also carry a non-deleterious ‘wild type’ allele for the same gene. The increased homozygosity caused by inbreeding leads to a higher frequency of individuals homozygous for deleterious alleles, and thus a reduction in the mean fitness of the population (see Waldman and McKinnon 1993 for a review).

It is important to note that there are little empirical data on inbreeding depression or substantial loss of genetic variability in any natural or hatchery population of Pacific salmon or steelhead, although there are considerable data on the effects of inbreeding in captive populations of rainbow trout (Hard and Hershberger 1995, quoted in Myers et al. 1998). However, a recent study of the effects of captive broodstock rearing of Redfish Lake sockeye found that over the study period (1991-2008) the program was effective in retaining 95% of the genetic variation in the population (Kalinowski et al. 2012). Studying inbreeding depression is particularly difficult in anadromous Pacific salmon because of their relatively long generation times, and the logistical complexities of rearing and keeping track of large numbers of families. Monitoring the rate of loss of molecular genetic variation in hatchery and naturally produced populations is one alternative method for studying the impacts of hatcheries on genetic variability (e.g., Waples et al. 1993), but does not provide information on inbreeding depression or other fitness effects associated with changes in genetic variation. Many of these changes are also expected to occur over many generations; so long-term monitoring is likely to be necessary to observe all but the most obvious changes.

Elwha Channel Hatchery Chinook salmon

The supportive breeding program for Chinook salmon may pose risks of within population genetic diversity loss for Elwha River Chinook salmon. A subset of the total run-at-large - 57% of the total estimated return (1999-2010 average WDFW 2012) – would be collected from the river for use as broodstock each year, and there is a potential that collections would not include a representative sample of remaining genetic diversity for the species.

As baseline for considering within population diversity loss risks, both the hatchery and natural population are likely to have diverged from the ancestral Elwha River population, due to the combined effects of artificial propagation and habitat alterations (NMFS 2003b). However, the Elwha Chinook salmon population remains unique among populations in the Puget Sound Chinook salmon ESU (Ruckelshaus et al. 2006), and the hatchery- and natural-origin aggregations in the river are genetically indistinguishable (NMFS 2003b). The Elwha Channel Hatchery program has been sustained for decades only through the collection of broodstock from the adult salmon population returning to the Elwha River (NMFS 2003b; WDFW 2012), and the resultant hatchery-origin fish are considered part of the Puget Sound Chinook salmon ESU and listed with the natural-origin population (70 FR 37160, June 28, 2005).

There is strong evidence that the WDFW hatchery program has been the primary means by which the Elwha Chinook salmon population has been preserved in the blocked and degraded river for at least the past 40 years. First generation hatchery-origin adults have been found to compose the vast majority of the listed species remaining in the Elwha River (WDFW 2012). The preponderance of fish composing annual returns (95-96% in recent years – WDFW 2012) are first generation hatchery-origin. Further, there is a strong likelihood that putative natural-origin fish remaining in the river are the progeny of naturally spawning hatchery fish, given the degraded state of the 4.9 miles of spawning and rearing habitat and estuary available to the species for 100 years. These factors lend support for implementation of the proposed program as the means to preserve remaining genetic diversity of the population over the short term, when the release of stored sediment is expected to cause up to 100% mortality of Chinook salmon spawned naturally in the lower river (Ward et al. 2008; NMFS 2006a; 2012a), and as river and estuary habitat recovers to properly functioning conditions supportive of natural production.

To mitigate risks under this category, broodstock collection, mating and artificial propagation measures are proposed that would minimize the risk of within population diversity loss of the remaining population. These measures would be implemented to minimize risk during the stock preservation and recolonization phases of restoration, and into the future. The risk of loss of within population genetic diversity in the hatchery and total populations resulting from implementation of the Elwha Channel Hatchery program would be minimized through the following proposed measures (WDFW 2012):

- The number of broodstock randomly collected from the river has averaged 1,075 adult fish per year to meet the goal annual broodstock collection objective of 1,700 fish (1999-2010 - WDFW 2012). Nearly all fish collected over this period were spawned and a high effective breeding population size was maintained – 4,874 fish in the most recent generation span (2006-2010), and 6,973 fish for the previous 5 brood year generational group (2001-2005). The effective breeding population size maintained through the program is sufficient in magnitude to minimize the risk of loss of within population diversity and rare alleles. Allendorf and Ryman (1987) report that less than 1% of the genetic variation would be lost each generation if N_e is maintained at a level greater than 50 breeding individuals. They recommended that at least 100 fish of each sex (200 individuals) be used to maintain a hatchery strain as a means to retain genetic variability of the population while under artificial propagation. Further, several other researchers concluded that the long-term adaptive potential of an isolated population (without migration into it) is conserved when N_e is on the order of 500 individuals (FAO - UN 1981; Nelson and Soule 1987). The proposed Elwha Channel Hatchery program would maintain an N_e that is much larger than these levels suggested to maintain propagated populations – 8,500 if goal collection levels are met for five consecutive brood years - reducing the risk of effective population size reduction and loss of within population genetic diversity for what remains of the extant Chinook salmon population in the river. An adequately high effective breeding population size would be maintained if the proposed annual broodstock collection objective of 1,700 fish is met.

- The sex ratio of the Chinook salmon population collected each year would be reflective of the run-at-large, and includes sufficient ratios of male and female fish.

- All fish collected through the mainstem weir, netting, gaffing, or as volunteers to the hatcheries would be used in the spawning operation, thereby reducing sources of bias that could lead to a non-representative sample of the broodstock.

- Factorial mating strategies applied through the program help ensure that all fish collected have an equal opportunity to contribute to the production of progeny, and the retention of diversity of the Chinook salmon population collected and spawned.

- Broodstock would be collected randomly from the mainstem river (mainstem weir, seines, gill nets, and hook and line) over the breadth of the total annual August through October adult return period (Figure 3 and Section 1.3.1). Because, based on historical averages, approximately 80% of all Chinook salmon collected as broodstock would be obtained through gaffing and netting operations directed at the population at large in the mainstem Elwha River (NMFS 2003b), there would be a high probability that natural-origin adults present will be collected and incorporated into the broodstock due to intentionally non-selective mainstem collection methods. These measures minimize the risk of selection for traits in broodstock that are not reflective of the run-at-large and that pose a risk of within population diversity loss.

- Fish surplus to hatchery needs will be transported live upstream above the dam sites to spawn naturally in areas unaffected by dam removal perturbations as a secondary supportive breeding action in the preservation phase, and a teritiary measure in the recolonization phase. This action would bolster the number of adult fish of the total population that would not be exposed to hatchery-related selection effects.

- Implementation of a genetic reserve program at Morse Creek Hatchery for up to 12 years would act as a safety net for preserving remaining genetic diversity of the Elwha Chinook salmon population. This contingency provides an additional or alternate broodstock collection source in the event of catastrophic loss of the population in the Elwha River watershed, for example, as a result of lethal turbidity and sediment levels from the release of stored materials as the dams are removed.

In summary, the within-population diversity of the remaining Elwha Chinook salmon population may be adversely affected by the proposed hatchery program. However, it is likely that supportive breeding provided through hatchery propagation over the past 40- 50 years has preserved the population. Existing genetic diversity, expressed by the total population, has resulted from, and has been substantially supported by, the hatchery program. Extant within population diversity for Elwha Chinook salmon is largely an artifact of any artificial selection that has likely occurred over the long term of operation of the hatchery program in a very degraded freshwater environment. Under this baseline, it has not been possible for natural production to contribute to total population diversity because natural production of adult fish that may contribute to natural spawning or broodstock incorporated through adult collections from the river has been very low. For these reasons, it is unlikely that the proposed Elwha Channel Chinook salmon hatchery program, operating over the term of the preservation and restoration phases of restoration and implemented as proposed with incorporation of mitigative measures, would adversely affect the remaining within population diversity of the Elwha Chinook salmon population.

Lower Elwha Fish Hatchery Native Steelhead Program

Implementation of the proposed native winter-run steelhead supportive breeding program may pose risks to natural population genetic diversity. Although the precise abundance of the spawning population in the river is unknown (perhaps 60 to 200 fish according to LEKT 2012a), it is possible that the hydraulic redd sampling methods did not did not result in broodstock that were fully representative of the annual run-at-large nor the total genetic diversity of the remaining native steelhead population.

If the above is true, it is likely that the effective size of the population would be reduced through broodstock collection practices and through supportive breeding that promotes improved hatchery fish survival to adult return relative to naturally spawned fish, risking loss of diversity of what remains of the species in the lower river. In short, like Chinook salmon, a subset of the total run-at-large would be collected from the river for use as broodstock each year, and there is a risk that collections would inadvertently not include a representative sample of remaining genetic diversity for the species in the propagated steelhead population that would be expected to have a higher survival rate to adult return than fish produced naturally. Additionally, as an artifact of the retention of fish in the hatchery for their entire life-cycleand if proper mating procedures are not followed, the captive broodstock strategy initially used as the primary supportive breeding method could pose substantial risk to within population diversity. Although no further brood years of steelhead are proposed to seed the captive population under the proposed action (the 2011 brood year was the last created), on-going production of captive adult fish and their progeny through 2015 may be of concern.

Germane to the evaluation of within population diversity reduction is the annual number and return timing of native steelhead that will be collected for use as broodstock relative to the total estimated spawning population. Collection of broodstock over the span of the adult return or spawning periods in the Elwha River would reduce the risk that fish used as broodstock are not representative of the remaining genetic diversity of the donor native stock population. The proposed program was founded starting with the 2004-2005 brood year, when 61 discrete redds were identified in the lower river for potential hydraulic egg/alevin sampling and collection of native stock fish for broodstock (LEKT 2006). Of the 61 redds, at least eight redds were dewatered during extreme low flow conditions that occurred. Approximately 1,200 eyed eggs and alevins were successfully obtained for use as broodstock from 22 redds of the 30 redds sampled (~57% of total number of viable redds identified) between April 26 and June 22, 2005. Eggs and alevins taken from each redd that year were treated as individual families and reared to broodstock size at the LEKT hatchery. For subsequent years, broods years (2005-2006 through 2009-2011), from 431 to 2,731 eggs/alevins were collected from late-returning steelhead redds each year for use in developing captive broodstocks. All (100%) of fish produced from these collections received PIT tags and were genetically analyzed to verify their origin, with the goal of producing 200 adult fish as captive brood. In summary, broodstock used to found the captive broods maintained at Lower Elwha Fish Hatchery may include a proportion of the genetic diversity retained in the current native winter-run steelhead population, but are not likely to include its total diversity. However, the collection of adult native steelhead returning to the river to spawn is expected to increase the potential for incorporating as broodstock existing genetic diversity of the native steelhead population to augment the captive broodstock.

Under both the preservation and recolonization phases, the proposed program would use a high percentage of the total returning native steelhead population collected over the breadth of the native steelhead return as broodstock in the supportive breeding effort. The annual number of adult fish spawned and collected from the river for use as broodstock will vary with restoration phase (preservation or recolonization), captive broodstock survival and resultant egg production levels, and the abundance status of adult fish returns to the river (LEKT 2012a). During the preservation phase (during dam removal and as lower river and estuary habitat recover from initial sediment impacts), the annual broodstock collection goal will reflect the intent to collect returning adult fish from the river, or utilize captive reared-adults, sufficient to maintain an annual on-station smolt release level of 175,000 fish. Through 2015, approximately 300 captive brood adult fish that were progeny of naturally spawning native steelhead, and up to 200 returning native stock adult fish, will be required to meet this smolt release objective. The total returning native steelhead population during this initial restoration phase would range up to perhaps 200 adults, so the proposed program would operate to use up to that number as broodstock, consistent with actions required by NMFS (2012a).

Native stock natural- and hatchery-origin adult steelhead collected from the river (mainstem weir, netting, volunteers to the hatcheries) would be retained as broodstock to meet the production objective during the preservation phase. During the recolonization phase, and after the captive broodstock portion of the program is terminated after 2015, adult broodstock collection needs from the river and from returns to the hatchery would increase to 500 fish, with collection of natural-origin fish or returning hatchery-origin adults (progeny of captive brood releases, with adult returns commencing in 2013). Under both these phases adult natural-origin steelhead collected from the river or escaping to the hatcheries that are surplus to annual hatchery broodstock objectives would be transported and released upstream of the dam sites into areas unaffected by dam deconstruction activities to spawn naturally (NMFS 2012a). The number of adult fish transported upstream during the recolonization phase would be determined by the censused number of steelhead that spontaneously colonize upper river spawning areas.

To further address risks under this category, broodstock collection, mating and artificial propagation measures will minimize the risk of within population diversity loss of captive broodstock under propagation and the remaining native winter-run steelhead population. These mitigative measures will be implemented to reduce the risk of this hazard over the term of program during the stock preservation and recolonization phases of restoration, when demographic risks to the population resulting from dam deconstruction would be greatest. Risk to within population genetic diversity in the hatchery population will be minimized through the following proposed measures implemented through the Lower Elwha Fish Hatchery native steelhead program (LEKT 2012a):

- The original donor source for the captive broodstock program through the proposed smolt release program in 2005 – 2011 were eggs collected from redds created by naturally spawning native Elwha River winter-run steelhead. Redds identified for hydraulic sampling and egg/fry removal were randomly selected from the total number of observed redds created during the March-April period when native winter-run fish spawn. Eggs and emergent fry were taken from multiple redd sites throughout the available watershed (LEKT 2012a).

- Captive broodstock adults produced for spawning will be augmented with natural-origin adults collected from the mainstem weir and by other means (as per NMFS 2012a). Adults retained as broodstock will be supplemented by hatchery-origin adult returns from BY 2005 – 2009 captive broodstock-origin smolt releases returning in 2013-2017.

- After the preservation phase of restoration, and as river habitat improves, the genetic diversity maintenance benefits of incorporating natural-origin adult fish as broodstock would be evaluated in light of their role in recolonization of the species through natural spawning. Guidelines would be developed for the program, considering ranges in the abundance and the likely availability of natural-origin steelhead in the short and long term phases of population recovery (LEKT 2012a).

- All steelhead broodstock utilized by the program would undergo genetic testing to verify their native Elwha River winter-run stock lineage to ensure that fish spawned are genetically part of the native steelhead population that spawn naturally. Through this action, the native stock genetic origin of the steelhead population propagated through the program would be maintained.

- Run timing for hatchery-origin fish would remain identical to the natural-origin population, because broodstock collected from the river from redds, through the mainstem weir, netting, or hook and line would be representative of the breadth of the total annual native steelhead return.

- There would be no selection effects for sex ratio or age since the primary source for fish reared to broodstock size for spawning through the proposed program would be progeny of naturally spawning native steelhead secured from redds as eyed eggs or fry.

- Appropriate mating practices will be applied in the captive broodstock program to minimize the risk of selection effects resulting in diversity loss. As described in section 8 of the HGMP (LEKT 2012a), fish spawned at Lower Elwha Fish Hatchery will be selected randomly from ripe fish on a given day. All gravid females will be scanned to determine identity (all captive broodstock fish are individually PIT tagged to identify brood year and family origin) and to identify appropriate mates.

- Mating guidelines and spawning matrices, developed in partnership with geneticists from the NMFS NWFSC, would be applied to conduct crosses with the goal of minimizing the risk of inbreeding and the loss of genetic diversity in the propagated population:
    - each female will be crossed with three males;
    - each female must be genetically unique from each of the three males;
    - each male spawned must be genetically unique from other males in a given mating;
    - each male may be used up to three times during the spawning season; and,
    - each female must be spawned individually, with each egg aliquot receiving milt from one of the three males.

In summary, the within population diversity of the remaining native Elwha River steelhead population may be adversely affected by the proposed captive breeding and juvenile steelhead release program because all adult fish composing the total populations were not likely used to create the captive broodstocks serving as the primary sources of progeny for smolt releases. However, for the reasons previously described, it is highly likely that supportive breeding is needed to preserve remaining diversity of the native winter-run population. The native population has been driven to critically low annual abundance levels, with substantial reductions in the diversity of the population relative to its historical baseline. Natural steelhead may potentially escape upstream into clear-water tributaries if the fish survive migration through inhospitable, and currently lethal, lower river turbidity conditions. However, the likelihood for substantial escapement and spawning by natural steelhead in unaffected areas is low, given the critical status of natural steelhead and adverse river survival conditions expected for at least the next three to six years. The remaining abundance and diversity of the population is therefore further threatened with extirpation as a result of dam deconstruction activities and effects on remaining lower river habitat.

Under the proposed action, existing genetic diversity expressed by the total population would be substantially supported by the proposed hatchery program for at least two brood cycles and perhaps longer, pending the rate of recovery of critical habitat. For these reasons, it is unlikely that the proposed Lower Elwha Fish Hatchery Native Steelhead program, operating over the term of the preservation and restoration phases would adversely affect the remaining within population diversity of the Elwha native winter-run steelhead population.

2.4.2.1.4.2. Outbreeding Effects

Outbreeding effects encompass diveristy and fitness change caused by gene flow from other populations. Genetic differences among salmon populations arise as a natural consequence of their homing tendency. Homing leads to a relatively high degree of demographic isolation among populations. This demographic isolation produces conditions where evolutionary forces such as natural selection and random genetic drift create differences in allele frequencies among populations. Many of these differences are believed to be adaptive – meaning that populations have been shaped by natural selection to have a particularly good fit to their local environment (see Taylor 1991, and McElhany et al. 2000 for reviews).

Although salmon and steelhead have a strong tendency to home to their natal sites, some return to other streams, a process called straying. The natural process and rate of straying has allowed salmonid populations over the course of thousands of years to colonize new habitats and to recolonize their former range (Pess et al., 2008 citing Quinn 1984, Hendry et al. 2004). Straying is common in salmon and steelhead but varies in pattern and intensity (Quinn 1993). Few empirical data exist that quantify rates of straying among natural salmon populations (particularly ones that have not been affected to some extent by hatchery programs), in part because of the substantial logistical difficulties involved in capturing and tagging sufficient numbers of natural-origin juveniles to provide the needed adult recovery data to reliably estimate the rate at which they return to non-natal streams. Most studies of stray rates have involved tagging of hatchery-produced juveniles. Quinn (2005) estimated that generally between 1 and 5% of returning adult salmon can be expected to stray. However, as summarized in Pess et al. (2008), stray rates vary substantially by species (Hendry et al. 2004) and natural-origin fish may stray at much higher rates. Pink salmon stray rates have been found to average 6% and range between 4 and 34%, while steelhead typically have stray rates that average 7%, and range between 5% and 26% (Hendry et al. 2004, Keefer et al. 2005). Within a given species, run-timing, different life history strategies, and species responses to environmental factors may also result in different stray rates. Germane to consideration of fish behavior responses to sediment and turbidity conditions in the Elwha River, the eruption of Mt. St. Helens drastically changed habitat conditions that provoked an immediate straying response in returning adult salmonids (Pess et al., 2008). Adult Toutle River steelhead straying rates increased from 16% to 45% after the eruption, with most strays moving to watersheds with lower turbidity (Pess et al., 2008 citing Leider 1989).

If strays reproduce, gene flow may result. Straying, and any gene flow, are thought to serve a valuable purpose in nature in terms of reducing loss of diversity through drift, and in colonization of vacant habitat. However, hatcheries can create unnatural gene flow situations, either in terms of sources or rates. Gene flow from unnatural sources or at unnatural levels can have two effects. One is simply a loss of among-population diversity. The genetic diversity contained in a population represents its adaptive potential. The more similar populations are made by gene flow, although there may be no discernible immediate consequence, the less they will be able to adapt differently to new environmental challenges. There is a clear negative correlation in several areas of the Pacific Northwest between among-population diversity and gene flow from hatcheries (e.g., Phelps et al. 1994), and changes to diversity have been seen in Europe as well (e.g., Ayllon et al. 2006). However, in other areas where hatchery production of non-native stocks has been extensive, native steelhead and Chinook salmon genotypes have been shown to persist (Phelps et al. 1994; 1997; Narum et al. 2006; Matala et al. 2012; G. Winans, NMFS, unpublished data, 2011). This does not mean that there has not been an effect on among-population diversity, but is rather a demonstration that intensive use of non-native hatchery fish does not necessarily result in genetic homogenization.

The other outbreeding effect is outbreeding depression, a loss of fitness in the first or subsequent generations after interbreeding. Outbreeding depression can be a simple loss of adaptation caused by changes in allele frequency or by the introduction of new alleles. In this case, results should be apparent the first generation after interbreeding. It can also result in the disruption of coadapted gene complexes, sets of alleles at different genes that work well together (Busack and Currens 1995, Naish et al. 2008). In this case, the effect is not observable until the second generation after the interbreeding event. The greater the geographic separation between the source and recipient population, the greater is likely to be the genetic difference between the two populations (ICTRT 2007). Therefore a hatchery-origin fish whose origins are geographically distant likely will genetically differ from a local natural population, regardless of additional differences that might develop due to the impact of the hatchery rearing environment (hatchery-induced selection- see below) resulting in outbreeding depression (Darwish and Hutchings 2009, Miller et al. 2004, Philipp et al. 2002). Such distant-origin hatchery fish therefore may pose a greater risk to the genetic character of a local natural-origin population than hatchery-origin fish originating from the same local natural-origin population.

Experimental designs to specifically test for outbreeding depression require control of the test organisms/populations over multiple generations (McClelland and Naish 2007, Naish et al. 2008). Such studies are therefore logistically difficult to set up, particularly for organisms with multi-year generation times and even more so for tests in a natural environment. As such, many published reports on hybridization/straying/hatchery stocking only provide results suggestive of outbreeding depression – see Hallerman (2003) for studies with aquatic organisms. Published studies presenting direct empirical evidence of outbreeding effects are few in number and come mostly from studies of plants in greenhouse settings, or invertebrates in laboratory settings - there are very few studies of outbreeding in vertebrates (Edmands 2007).

There are a few noteworthy studies of outbreeding depression in fish. Gharrett et al. (1999) created F1 and F2 hybrids between even- and odd- year pink salmon. No differences in adult return rates were observed between F1 and control fish, but there was a statistically significant difference between F2 fish and the controls – indicative of outbreeding depression via disruption of coadapted gene complexes. The two populations were highly isolated genetically due to lack of natural interbreeding between odd and even year fish.

In another study of pink salmon, Gilk et al. (2004) compared return rates between native control pink salmon (both odd and even year) and F1 and F2 hybrids with a population whose natal stream was at a similar latitude, but over 1000 km distant. Return rates for odd- year F1 hybrids and controls were similar, and similar to results of Gharett et al. 1999. In contrast, even-year F1 hybrids returned at a rate statistically significantly lower than that of controls - suggesting a lack of outbreeding depression in the odd year crosses, but presence of an effect in the even year crosses. In both even and odd year crosses, however, the F2 fish showed a statistically significant lower return rate relative to controls, suggesting disruption of coadapted gene complexes.

Dann et al. 2010 created control crosses and F1 and F2 hybrids with a native coho stock and two other SE Alaska hatchery stocks (the furthest hatchery of the two being 500 km distant), and compared return rates. They observed no statistically significant differences between any of the F2 and control groups, indicative of a lack of outbreeding depression. And, in comparisons between F1 hybrids and controls they actually observed an increase in survival of the F1 relative to the controls – an unexpected incidence of heterosis (hybrid vigor). The authors attribute the lack of evidence for outbreeding depression to low power (limited sample size) of their study, and possibly to diminished genetic isolation of the three stocks. Darwish and Hutchings (2009) compared Atlantic salmon backcrosses that differed only in the population originally outcrossed to, and found statistically significant differences in reaction norms in several traits. Philipp et al. (2002) found that Illinois largemouth bass (*Micropterus salmoides*) had much higher reproductive success in an Illinois test pond than an introgressed population descended from bass from Illinois and two other states.

A salient characteristic of all these studies is the use of distantly related populations, presumably chosen to detect an effect. The largemouth bass example is relevant to management of that species, because the geographical separation of the test populations is representative of the long-distance transplants that largemouth bass have been subjected to. The salmon examples, however, involve populations that are geographically or genetically separated much more than populations that are likely to have gene flow between them. It is unclear how much outbreeding depression can be expected from genetic exchange between populations with similar life histories within an ESU/DPS, or even between ESUs/DPSs.

To deal with this issue, a 1995 NMFS-sponsored workshop focused on the biological consequences of hatchery fish straying into natural salmonid populations (Grant 1997). The workshop addressed how much gene flow can occur and still remain compatible with the long-term conservation of local adaptations and genetic diversity among populations. Based on selection effects in other animals, the workshop expert panel hypothesized that a gene flow rate of greater than 5 percent between local and non-local salmon populations would quickly lead to replacement of neutral and locally-adapted genes (Grant 1997). NMFS notes that gene flow is expected to be much less than 5 percent when the stray rate of non-local fish into a local population is 5 percent because not all fish that stray will spawn successfully. NMFS supports the standard that hatchery stray rates should be managed such that less than 5 percent of the naturally spawning population consists of hatchery fish from a different area. Furthermore, the number of non-local strays in a particular population should be as low as possible to minimize outbreeding effects.

It is important to note that genetic differences between populations may or may not include hatchery-induced selection effects, but the outbreeding effects discussed above result from genetic differences between distinct populations due to their origins, apart from hatchery-induced selection. These effects are not the same as those arising from the interbreeding between the hatchery and natural-origin components of a single population.

Measures to reduce the risk of outbreeding effects may include:

- Propagating and releasing only fish from the local indigenous population or spawning aggregate.

- Avoiding or adequately reducing gene-flow from a hatchery program into natural populations located in watersheds where the hatchery fish may stray.
- Limiting the transfers of fish between different areas.
- Acclimating hatchery fish in the target watershed to ensure that the hatchery fish retain a high fidelity to the targeted stream (Clarke et al. 2010).
- Using returning spawners rather than the transferred donor population as broodstock for restoration programs to foster local adaptation.
- Maintaining natural populations that represent sufficient proportions of the existing total abundance and diversity of an ESU/DPS without hatchery intervention.
- Marking all hatchery-produced salmonids to allow for monitoring and evaluation of straying and contribution to natural production (Kapuscinski and Miller 1993; Flagg and Nash 1999).

Elwha Channel Hatchery Program

The Elwha Channel Hatchery program has been sustained for decades only through the collection of broodstock from the adult salmon population returning to the Elwha River (NMFS 2003b; WDFW 2012). Broodstock will continue to be collected only from the Elwha River, and from Morse Creek, where a reserve population has been established through hatchery out-plants using fish from the Elwha Chinook salmon population. The risk of outbreeding depression associated with implementation of the program would therefore be unsubstantial.

Germane to considerations regarding expected outbreeding effects on listed salmon and steelhead populations in adjacent watersheds (e.g., Dungeness River) would be the probability of Elwha hatchery-origin Chinook salmon straying from their release locations and the proportion of spawners in the receiving watersheds composed of Elwha strays. Morse Creek Hatchery is part of the Elwha Channel Hatchery program, serving as the juvenile rearing and release and adult return location for transplanted Elwha Chinook. The program there was designed as a genetic reserve for the Elwha population for fish restoration purposes (Ward et al. 2008; WDFW 2012). Chinook salmon in Morse Creek were considered part of the Elwha Chinook salmon population prior to initiation of the gene-back effort (WDF et al. 1993; Ruckelshaus et al. 2006). For these reasons, straying of adult hatchery-origin Elwha Chinook salmon into Morse Creek does not pose outbreeding risks to the Chinook salmon in Morse Creek. As the next major and proximate watershed eastward of the Elwha River, the Dungeness River may be a location where Elwha Chinook salmon stray. The Dungeness Chinook salmon population is a distinct independent population. Straying of adult fish trying to avoid turbid conditions in the Elwha River may pose outbreeding depression risks to the native Dungeness population. Evaluating the effects of any such strayingbetween the populations would consider the geographic proximity of the two populations, their inclusion in the same biogeographical region as related populations (Ruckelshaus et al. 2006), and their genetic similarity to the populations in the biogeographical region relative to other Puget Sound Chinook salmon ESU populations. Because of their geographic location, Dungeness River Chinook salmon were often presumed to be genetically intermediate between Elwha River Chinook salmon and those from east Puget Sound tributaries (Ruckelshaus et al. 2006). However, genetic analyses of Elwha Chinook salmon and juvenile Dungeness Chinook salmon did not support that presumption. Data show equal or greater divergence of Dungeness River Chinook salmon from other groups in Puget Sound (Ruckelshaus et al. 2006).

There are no data indicating that Elwha Chinook salmon stray into the Dungeness River and spawn with Dungeness Chinook salmon, so stray rates and outbreeding depression risks are unknown. Measures will be implemented through the Elwha Channel Hatchery program to reduce the risk of outbreeding depression and straying resulting from adult hatchery-origin fish returning to the Elwha River and Morse Creek release sites:

- The program will propagate and release only fish from the local indigenous Elwha River population, and any straying into adjacent watersheds where other natural-origin Chinook salmon populations exist is not expected to result in among population genetic diversity reduction.

- Juvenile fish reared by the program will be adequately acclimated to their sites of release in the Elwha River and Morse Creek watersheds to help ensure that the hatchery fish retain a high fidelity to their release sites as returning adults.

- Returning spawners, localized to their release sites, rather than transferred fish will be used as broodstock to further foster local adaptation, and limit straying potential.

- All juvenile fish released by the program will be marked with wire tags and/or otolith marks to allow for monitoring and evaluation of straying and the contribution of Elwha River hatchery-origin Chinook salmon to natural production in watersheds where adult fish may potentially stray.

- The primary off-station supportive breeding fish release strategy of trucking and releasing adult fish for natural spawning above the dam sites over the term of the preservation and recolonization phases is expected to foster greater fidelity of adult salmon returns to the Elwha River when compared to adult fish returns produced by other hatchery release strategies (e.g., truck-planted smolts). Stray rates for adult fish resulting from this release strategy will be expected to mimic rates exhibited naturally by the species and any outbreeding depression risks to adjacent natural-origin Chinook salmon populations would not be elevated above baseline natural levels.

Lower Elwha Fish Hatchery Native Steelhead Program

Germane to considerations regarding outbreeding effects on adjacent listed steelhead populations within the Puget Sound steelhead DPS would be the probability of Elwha River hatchery-origin steelhead straying and the proportion of spawners in the receiving watershed composed of strays. The winter-run steelhead hatchery program propagates the native Elwha River stock, and outbreeding depression effects on the remnant natural population in the Elwha River is not a risk factor. Adjacent watersheds harboring independent natural populations of steelhead where Elwha River hatchery-origin steelhead might stray and spawn include Morse Creek, Dungeness

River, and miscellaneous tributaries to Sequim and Discovery bays (WDF et al. 1994; PSSTRT 2012).

Until recently, production of winter-run steelhead in the Elwha River basin included releases of out-of-basin origin Chambers Creek hatchery-lineage winter-run steelhead, a population that is excluded from the DPS listing. This early-returning stock was propagated by LEKT at Lower Elwha Hatchery beginning in 1976 to provide fish for harvest. Prior to that time, and continuing through the mid- 2000s, WDFW also released Chambers stock steelhead into the Elwha River through truck plants. All Chambers Creek-lineage steelhead have been marked with an adipose fin-clip beginning with releases in the mid-1990s to allow for their directed harvest, and to help minimize incidental takes of native stock Elwha River steelhead in fisheries. Considering the need to reduce the risk of among population diversity loss to the native winter-run steelhead population, the LEKT terminated the Chambers steelhead program following the last release of smolts in 2011. The last adult returns of Chambers Creek-lineage steelhead will be in winter, 2013-2014. Genetic analyses by the NMFS NWFSC of four brood years of naturally spawned Elwha steelhead collected from redds in 2005, 2006, 2007 and 2008 showed no trace of Chambers Creek steelhead genetic introgression (G. Winans, unpublished data, December, 2011). Outbreeding depression effects on the native Elwha River steelhead population of the now terminated LEKT program appear to have been unsubstantial. As a further measure to reduce genetic diversity risks, the LEKT has conducted directed fisheries administered by tribal fisheries management staff in 2012-2013 and 2013-2014 to remove Chambers Creek origin steelhead (LEKT 2012a). The co-managers will also keep hatchery weirs and traps open, and operate the mainstem Elwha River weir if feasible; to collect and cull any Chambers origin steelhead that are encountered (LEKT 2012a).

The first hatchery releases of native Elwha River winter-run steelhead smolts occurred in 2011, and the first adults from the releases are expected to return in 2013. There are therefore no data yet available regarding stray rates for adult fish produced through the program that would potentially pose outbreeding depression risks to neighboring steelhead populations. However, genetic analyses of four years of broodstock propagated through the program indicates that steelhead from the Dungeness River-population have contributed substantially to the genetic structure of the Elwha River population (G. Winans, NMFS, unpublished data, December, 2011). These analyses also showed that steelhead from other natural populations in Puget Sound have strayed into and affected the current genetic character of Elwha Riversteelhead. A distinct genetic signature for Elwha River steelhead persists, however.

Measures will be implemented through the Lower Elwha Fish Hatchery program to reduce the risk of straying and outbreeding depression to other populations from the Elwha River native winter-run steelhead program:

- The program willpropagate and release only fish from the native Elwha River population. Any effects on the Dungeness population would be unsubstantial, as the steelhead population in the Dungeness River is genetically similar.

- Harvest in fisheries targeting early-timed, hatchery-origin steelhead in 2012-13 and 2013-14 would occur to reduce the risk that the last remaining adult returns of early-timed Chambers lineage stock would escape into natural spawning areas and interbreed with native late-retuning winter-run steelhead.

- Weirs and traps at Lower Elwha Fish Hatchery, the old Lower Elwha Hatchery, Elwha Channel Hatchery, and (if feasible with flows) the mainstem Elwha River weir will be operated to collect and cull marked, early-returning Chambers lineage adult steelhead in 2012-13 and 2013-14 to remove the fish from the river, preventing their spawning and thereby reducing risk to Elwha steelhead diversity.

- Juvenile fish reared through the program will be adequately acclimated to their hatchery site of release in the lower Elwha River to ensure that the fish retain a high fidelity to the release site as returning adults, rather than straying upstream with the natural-origin fish.

- Returning spawners, localized to their hatchery release site, rather than transferred natural-origin fish, would be used as broodstock when native stock adult returns are established (2013) to further foster local adaptation, and limit straying potential.

- All juvenile fish released through the program will be marked with wire tags and otolith marks to allow for monitoring and evaluation of straying and the contribution of Elwha River hatchery-origin steelhead to natural production in watersheds outside of the Elwha River.

- The primary off-station supportive breeding release strategy of trucking and releasing adult fish for natural spawning above the dam sites over the term of the preservation and recolonization phases would foster greater fidelity of adult steelhead returns to the Elwha River when compared to adult fish returns resulting from other hatchery release strategies (e.g., truck-planted smolts). Stray rates for adult steelhead resulting from this release strategy would be expected to mimic rates exhibited naturally by the populations and any outbreeding depression risks to adjacent natural-origin steelhead populations would not be elevated above baseline natural levels.

2.4.2.1.4.3. Hatchery-Induced Selection (“Domestication”)

Hatchery-induced selection (commonly called “domestication”[5]) pertains to fitness loss and phenotypic change caused by differences between the hatchery and natural environments (includes intentional selection and relaxation of selection), and sampling “errors” during fish culture. Hatchery-induced selection may lead to changes in quantity, variety and the combination of alleles between a hatchery population and its source population that are the result of selection in the hatchery environment (Busack and Currens 1995). This hazard is also defined as the selection for traits that favor survival in a hatchery environment and that reduce survival in

[5] For the purposes of this opinion, the discussion of salmon and steelhead hatchery-related genetic effects encompassing intentional selection, biased sampling, or unintentional selection will refer to “hatchery-induced selection” rather the term “domestication.” Although widely used in the scientific literature, the latter term is more appropriately applied to animal species that are retained for their entire life spans in captivity. By contrast, hatchery-origin salmonids, upon release, are exposed to intense natural selective pressures for substantial proportions of their life spans, varying from 33% to 95% dependent upon the species.

natural environments (NMFS 1999b). Hatchery-induced selection can result from rearing fish in an artificial environment that imposes different selective pressures than what they would encounter in the wild for the spawning, incubation and juvenile rearing portions of their life history. The concern is that hatchery-induced selection effects will decrease the performance of hatchery fish and their descendants when exposed to natural selection conditions in the wild. Busack and Currens (1995) identified three types of hatchery-induced selection:

(1) *Intentional or artificial selection* represents purposeful attempts to change the population to meet management needs, such as time of adult return or spawn time. Hatchery fish selected to perform well in a hatchery environment tend not to perform well when released into the wild, due to differences between the hatchery and the naturally produced populations resulting from the artificial propagation. Natural populations can be impacted when hatchery adults spawn with natural-origin fish and the performance of the natural population is reduced (a form of outbreeding depression) (Busack and Currens 1995).

(2) *Biased sampling during some stage of culture* leading to hatchery-induced selection can be caused by errors during any stage of hatchery operation. Broodstock selection is a common source of biased sampling when adults are selected based on particular traits. Hatchery operations can be a source of biased sampling when groups of fish are selected against when feeding, ponding, sorting and during disease treatments because different groups of fish will respond differently to these activities.

(3) *Unintentional or relaxed selection* may cause genetic changes to occur because salmon and steelhead in hatcheries usually have (by design) much higher survival rates during the incubation and juvenile rearing periods compared to survival rates in the wild. Hatchery fish are propagated in a sheltered environment that increases their survival relative to similar life stages in the natural environment, potentially allowing deleterious genotypes that would have been lost in the natural environment to contribute to the next generation.

Reisenbichler and Rubin (1999) cite five studies indicating that hatchery programs for steelhead and stream-type Chinook salmon (i.e., programs holding fish in the hatchery for one year or longer) genetically change the population and thereby reduce survival for natural rearing. The authors report that substantial genetic change in fitness can result from traditional artificial propagation of salmonids held in captivity for one quarter or more of their life. Bugert et al. (1992) documented morphological and behavioral changes in returning adult hatchery spring Chinook salmon relative to natural adults, including younger age, smaller size, and reduced fecundity. However, since that study, differences in size and age at return have been found to be more related to smolt size at release than hatchery-induced selection. Differences in fecundity may still be observed (although see Knutsen et al. 2008), but the cause is not fully understood.

Leider et al. (1990) reported diminished survival and natural reproductive success for the progeny of non-native hatchery steelhead when compared to native naturally produced steelhead in the lower Columbia River region. The poorer survival observed for the naturally produced offspring of hatchery fish could have been due to the long term artificial and hatchery-induced selection in the hatchery steelhead population, as well as maladaptation of the non-indigenous hatchery stock in the recipient stream (Leider et al. 1990).

Research on winter steelhead in the Hood River basin that capitalized on many years of genetic sampling at Powerdale Dam (demolished in 2010) has yielded several publications on relative reproductive success and fitness loss based on pedigree analysis. Because of the number of publications, their striking results, and high visibility, they need to be discussed in some detail. The following is just a review of major findings. There have been two phases to the Hood River steelhead research. The first phase was reproductive success of hatchery-origin fish relative to natural-origin fish in the wild. Blouin (2003) compared the reproductive success (in terms of returning adult steelhead) on the spawning grounds relative to natural-origin spawners of three types of hatchery-origin spawners: a non-native winter-run stock (Big Creek), a non-native summer-run stock (Skamania), and a native winter-run stock recently begun as a supplementation effort. Both the non-native stocks had been under hatchery culture for many generations. He initially found that the relative reproductive success (RRS) of the non-native winter-run fish was 34-35%, the RRS of the non-native summer-run fish was 17-54% and the RRS of the native winter-run supplementation program fish was 85-108%. In subsequent reports (Blouin and Araki 2004, Blouin and Araki 2005, Blouin and Araki 2006) these estimates were refined through improvement in statistical methods, increases in sample sizes and the number of brood years analyzed and correction for harvest, resulting in a peer-reviewed publication - Araki et al. (2007). They found that RRS for males was 5.6% and for females 10.6% for the non-native winter run (a statistically significant change over the 2003 results), for males 40.5% (39.7-42.1) and for females 44.4% (44.2-45.0) for the non-native summer run, and for males 106% (71-132) and for females 118% (80.5- 156) for the native winter-run supplementation program fish. The results from this work seem clear. The non-native stocks are much less successful at reproducing in the wild than natural-origin fish, whereas the native supplementation program hatchery-origin spawners range from about 30% less successful to 50% more successful, and on average about the same as the natural-origin fish. The authors concluded, based on the high RRS of the hatchery-origin supplementation fish, that supplementation can be used to give a population a single-generation demographic boost without adverse genetic consequences. They cautioned, however, that the long-term fitness consequence of supplementation was still an open question.

The second phase of the Hood River steelhead work was based on the second generation of hatchery fish produced by the supplementation program. The program began incorporating returning hatchery fish into the broodstock, so hatchery matings were 1/3 WxW and 2/3 HxW, producing two classes of returning adults (Blouin and Araki 2007). Araki et al. (2007) compared the RRS of these of these two classes of fish spawning in the wild, and found that the fish with WxH parentage had 54.6-60.9% the reproductive success of the fish with WxW parentage. Because the fish were subjected to the same environmental conditions and because it made no difference in the WxH fish which sex had been the hatchery-origin parent (ruling out maternal effects), they concluded the difference in reproductive success had a genetic basis. They also conducted a meta-analysis of reproductive success of hatchery fish in the wild, adding their data to those from existing studies, and found a good exponential fit suggesting a fitness loss of 37.5% per captive generation. It is important to remember that this rate of fitness loss was a result of the meta-analysis, and not a direct result of their research. The overall conclusion of the paper was that whatever the cause of the fitness decline, fitness can decline rapidly so repeat use of hatchery fish should be carefully considered.

Araki et al. (2008) considered the question of whether hatchery-induced selection is a sufficient explanation for the sharp fitness decline observed by Araki et al. (2007) and in other studies, using a simple genetic model and empirical information available from salmonids. They concluded that hatchery-induced selection is a plausible explanation for such large declines, but that other genetic factors may also be involved, such as epigenetic change, chromosomal abnormalities, relaxation of selection, or enhanced mutation.

Blouin et al. (2010) investigated one possible source of epigenetic change, methylation of DNA bases, and found no evidence the hatchery environment was enhancing methylation. In a fundamental shift from the earlier work, which had only considered the fitness of hatchery-origin fish spawning in the wild, Araki et al. (2009) considered the question of whether the reproductive success of natural-origin fish was influenced by hatchery ancestry, comparing the reproductive success in the wild of natural-origin fish that had 0, 1, or 2 hatchery-origin parents. Although results varied over the three return years, there was little difference between the sexes. Fish with one hatchery-origin parent were 87% as successful as fish with no hatchery-origin parents, but fish with two hatchery-origin parents were only 37% as successful. They concluded that the generation in the wild did not erase the genetic effect of the hatchery. In contrast to the findings from these studies of Hood River steelhead trout, Ford et al. (2012) found little evidence that parental origin of the captive spawners influenced the subsequent reproductive success of their naturally spawning progeny. Through a three-generation pedigree evaluation of an artificially supplemented Chinook salmon population, their research showed that the fish with the highest reproductive success in captivity produced early maturing male offspring that have lower than average reproductive success in the wild. They also showed that, again in contrast to the Hood River steelhead study findings, there was little evidence that the use of wild origin fish as broodstock influenced the reproductive success of their progeny – a finding consistent with observed high rates of exchange between the hatchery and natural environments in the study population (Ford et al. 2012).

Most of the empirical evidence of hatchery selection comes from studies of species – mostly steelhead - that are reared in the hatchery environment for an extended period - one to two years - prior to release. For the purpose of this opinion, it is also important to understand hatchery-induced selection risks to Chinook salmon that may result from hatchery production of the species. Chinook salmon are very different, with the majority (94%) in the Puget Sound region reared for just a few months (3 to 4) in the hatchery environment prior to their release into the natural environment, where they spend upwards of 93% of their 4 to 5 year life spans. This species, released predominantly from hatcheries as sub-yearlings, is therefore exposed to artificial propagation and potential hatchery-induced selection effects to a much smaller extent than steelhead, which return as 3- to 4-year-old adults, but may be retained in the hatchery for 1 to 2 years prior to release. After their release from the hatchery, sub-yearling hatchery-origin Chinook salmon are exposed to natural selective pressures, also affecting commingled natural-origin fish of the same species, that would potentially cull traits unfit for survival in the wild to a much larger extent than steelhead. Researchers and managers alike have wondered if the results described above for steelhead could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies, including Chinook salmon.

To investigate this question, the RIST (2009) reviewed and summarized 18 published and unpublished studies that directly estimated the fitness of hatchery-origin fish relative to natural-origin salmonids. Most of the studies (17) evaluated anadromous salmonid species that exhibit a life-history pattern typified by at least one year of rearing in freshwater (i.e., yearlings). No studies have been conducted to investigate the relative reproductive effectiveness and fitness of sub-yearling hatchery Chinook salmon or to determine hatchery-related fitness effects associated with the production of subyearling Chinook salmon, like those in Puget Sound (California HSRG 2012). In summarizing study results, RIST (2009) reported that, among hatchery-origin stocks that were propagated for less than five generations, average relative fitness across studies was 0.65 for steelhead (n = 3; range 0.31 to 0.85), 0.75 for Atlantic salmon (n = 1), 0.85 for Chinook salmon (n = 4; range 0.52 to 1.16) and 0.83for chum salmon (n = 1). A relative fitness of 0.83 means that hatchery fish in the study were only 83 percent as fit as a natural-origin fish. These results need to be interpreted with care in making comparisons of hatchery-origin and natural-origin fish from the same population and expected fitness loss in subsequent generations, in part, because it is unclear how much of the difference is genetic (rather than environmental) and heritable from one generation to the next (e.g., Araki et al. 2009), and how much is attributable to developmental history (Galbreath 2010; California HSRG 2012).

As noted, no studies have been conducted to investigate the relative reproductive effectiveness and fitness of hatchery sub-yearling program-origin Chinook salmon or to determine hatchery-related fitness effects associated with the production of subyearlings of this ocean-type race. Because hatchery sub-yearling Chinook salmon represent the vast majority of releases of the species in Puget Sound, NMFS considers collection of pertinent data on fitness impacts and testing of hypotheses regarding risk reduction approaches a high priority for fish produced by sub-yearling Chinook salmon hatchery programs. In a recent review of salmon and steelhead hatcheries in California, where the majority of programs also release sub-yearling, ocean-type Chinook salmon, the California HSRG reached the same conclusion to appropriately guide future management of such programs (California HSRG 2012). In the interim and in general, NMFS expects hatchery operators to develop and implement HGMPs that achieve meaningful reductions in genetic effects. However, under circumstances where the demographic risk faced by a natural population outweighs risks from hatchery intervention, hatchery fish derived from the local extant population may be encouraged to spawn naturally at relatively high proportions of total escapements. Responses to concerns regarding the genetic impact of hatchery programs in the near term will therefore be considered on a watershed-specific basis and take into account the demographic strength and genetic diversity of the affected natural population(s), the existing and projected productivity of habitat in the watershed, and other issues relevant to the viability of the populations.

As tempered by the above considerations, hatchery-induced selection effects from artificial propagation and the level of genetic differences between hatchery and natural fish can be minimized by:

- Randomly selecting adults for broodstock from throughout the natural population migration to provide an unbiased sample of the natural population with respect to run timing, size, age, sex ratio, and other traits identified as important for long term fitness.

- Ensuring that returning adults used as broodstock by a hatchery continually incorporate natural-origin fish over the duration of the program to reduce the likelihood for divergence of the hatchery population from the natural population.
- Limiting the duration of a supplementation program to a maximum of three salmon generations (approximately 12 years) to minimize the likelihood of divergence between hatchery broodstocks and target natural stocks and to reduce the risk of hatchery induced selection of the composite hatchery/natural stock.
- Employing appropriate spawning protocols to avoid problems with inbreeding, genetic drift and selective breeding in the hatchery (e.g., Simon et al. 1986; Allendorf and Ryman 1987; Gall 1993). Methods include collection of broodstock proportionally across the breadth of the natural return, random matings with respect to size and phenotypic traits, application of at least 1:1 male to female mating schemes (Kapuscinski and Miller 1993), and avoidance of intentional selection for any life history or morphological trait.
- Using spawning protocols that equalize as much as possible the contributions of all parents to the next breeding generation.
- Using only natural fish for broodstock in the hatchery each year to reduce the level of hatchery-induced selection.
- Setting minimum broodstock collection objectives to allow for the spawning of the number of adults needed to minimize the loss of alleles and the fixation of others (Kapuscinski and Miller 1993).
- Setting minimum escapements for natural spawners and maximum broodstock collection levels to allow for at least 50 percent of escaping fish to spawn naturally each year, to help maintain the genetic diversity of the donor natural population.
- Using hatchery methods that mimic the natural environment to the extent feasible (e.g. use of substrate during incubation, exposure to ambient river water temperature regimes and structure in the rearing ponds).
- Limiting the duration of rearing in the hatchery by releasing fish at early life-stages to minimize the level of intervention into the natural salmonid life cycle, minimizing the potential for hatchery-induced selection.

NMFS believes that the above measures for minimizing the potential adverse genetic impacts of hatchery produced fish on natural populations should be applied to protect listed species. The actual measures selected will depend on a number of factors including but not limited to:

- Program objectives (i.e. recovery, reintroduction or harvest augmentation).
- Broodstock source, history and level of exposure to hatchery-induced selection.
- Spawning protocols.
- Status of the natural population targeted by the hatchery program.
- Threats posed to the current and future viability status and/or critical habitat of the targeted natural population.
- Ability of fish managers to remove or control the number of hatchery adults in the natural spawning population.
- Rearing practices.

- Total number of hatchery fish released into the subbasin.

Additional, detailed discussions on the measures to implement these strategies can be found in Reisenbichler (1997), Reisenbichler and McIntyre (1986), Nelson and Soule (1987), Goodman (1990), Hindar et al. (1991), and Waples (1991) among others.

Elwha Channel Hatchery Chinook salmon Program -

As noted previously, the Elwha Channel Chinook salmon hatchery program has operated for decades and has been sustained through the collection of broodstock from the adult salmon population returning to the Elwha River (NMFS 2003b; WDFW 2012). Over the span of operation considered in this opinion (the preservation and restoration phases), broodstock would continue to be collected only from the Elwha River, and from Morse Creek, where a reserve population has been established through out-plants of Elwha Chinook salmon stock. The majority of juvenile fish (86%) would be released as sub-yearlings after 3 to 4 months of rearing, with the remainder (14%) released as yearlings after one year in the hatchery (WDFW 2012).

Based on currently available scientific information, the proposed program would likely result in some hatchery-induced selection risks to the Chinook salmon population remaining in the Elwha River. Some degree of effects associated with this hazard would likely be unavoidable for the program, given that not all adult fish of aggregate hatchery- and wild-origin returning to the Elwha River each year are collected and retained as broodstock. Rearing of fish to sub-yearling or yearling size would confer further selection risks as the fish are propagated in an artificial, rather than a natural, setting.

In an earlier review of the Elwha Channel Hatchery program, the HSRG concluded that the program had succeeded in preserving the Elwha Chinook salmon stock over a long period of time, under challenging conditions (HSRG 2002b). Affirming this finding were recent data revealing that naturally spawning Chinook salmon are almost entirely of hatchery-origin, with the estimated natural-origin abundances ranging between74 and 102 adult fish for two brood years evaluated (2004 and 2005 - WDFW 2012). Considering the blocked and degraded state of natural-habitat, the hatchery program, operating for over four decades, has likely preserved what remains of the genetically unique Elwha Chinook salmon population. This conclusion was affirmed in NMFS' ESA listing decision that included Elwha hatchery Chinook salmon in the Puget Sound Chinook Salmon ESU.

This new information regarding the status of natural-origin Chinook salmon in the Elwha River was one factor leading the EMG (2012) to conclude that it will be impossible for the Elwha Channel Chinook salmon Hatchery program to meet percent hatchery-origin fish spawner contribution (i.e., PHOS and PNI) goals that would help limit the risk of hatchery-induced selection during the early stages of restoration. They specifically recommended against PNI goals for the preservation and re-colonization phases (EWG 2012). This recommendation was based on the conclusion that the current stock composition has largely been maintained through the hatchery program and hatchery returns far exceed natural-origin returns for Chinook salmon. In addition, recent data (otolith data) suggests that the productivity of natural spawning adults does not replace the natural spawners (EMG 2012), a situation that would likely continue through the early stages of fish restoration, since the hatchery would be used to preserve the stock during the period when high turbidities associated with dam removal exist. The EMG noted that the expected high turbidity levels resulted in NMFS requirements in the dam deconstruction consultation with NPS for broodstock collection at levels that would fully seed the Elwha Channel Hatchery Chinook salmon program during the period of high turbidity to ensure the Elwha Chinook salmon stock is preserved (NMFS 2006a; NMFS 2012a).

In view of the management history of the Chinook salmon population (e.g., hatchery-origin fish have likely composed the majority of Chinook salmon spawning naturally in the river for decades; mainstem river broodstock collection practices have led to the collection of fish representative of the total returning run), hatchery intervention as described in the HGMP is not likely to lead to large further hatchery-induced selection risk during the preservation and recolonization phases (HSRG 2012), which cover the duration of the proposed action. The group also concluded that the off-site hatchery Chinook salmon program, located on Morse Creek, would reduce the risk of losing remaining genetic resources during the preservation and recolonization phases, when habitat is unstable (HSRG 2012).

Considering the severely depressed abundance status of natural-origin Chinook salmon returns (section 1.3.1), very low productivity of fish spawning naturally in conditions prior to dam removal (section 1.3.1), and the expected elevated threat to fish survival and productivity during and for a period after dam removal due to sediment loads, the demographic risk faced by the natural population outweighs any hatchery-induced selection risks that would result from hatchery intervention as described in the Elwha Channel Hatchery HGMP. Hatchery-origin fish derived from the local extant Chinook salmon population will be encouraged to spawn naturally during the earliest phases of fish restoration, as a means to preserve and rebuild the total abundance of the population, and retain what remains of the diversity of the Chinook salmon population. These perspectives, regarding the acceptability of genetic effects associated with the proposed program, take into account the compromised demographic strength of the remaining natural Chinook salmon population, the proportion of total genetic diversity retained in the current hatchery program over the long and short term, the existing impaired, and further threatened condition of critical Chinook salmon habitat over the short term, and expectations for improved productivity of habitat in the watershed as the lower river heals and a functioning estuary is restored.

Genetic risk management measures, consistent with measures described in NMFS (2012b), are proposed in the HGMP to reduce the risk of intentional or unintentional hatchery-induced selection and biased sampling effects on Elwha Chinook salmon population diversity over the preservation and recolonization phases of restoration (from WDFW 2012):

- Broodstock used to sustain the program each year will be Elwha Chinook salmon collected from the run-at-large adult returns to the Elwha River and Morse Creek. Out-of-basin strays from other Chinook salmon populations will not be knowingly spawned or incorporated into the gene pool.

- Broodstock would be collected randomly across the breadth of the adult return timing, and be representative of the age class distribution and sex ratio for the species, from the combined number of fish collected at the Elwha Channel Hatchery weir, mainstem river trap, Lower Elwha Fish Hatchery, and from the lower mainstem river (through seining, gillnetting, or hook and line capture).

- In collecting adult Chinook salmon randomly from the total run-at-large in the mainstem river, natural-origin adults will be included annually as hatchery broodstock, which should assist in maintaining genetic similarity between first generation hatchery and naturally produced fish, reducing the risks of hatchery-induced selection effects.

- In-river activities implemented to collect broodstock that would harm naturally spawning Chinook salmon productivity, and potentially population diversity, will be minimized to reduce negative impacts on actively spawning fish and redds.

- The survival and diversity of the population collected from the mainstem river through netting or gaffing and maintained for spawning until maturity would be enhanced by holding the fish in well water. Typically, surface water from the Elwha River would not be used to hold adults, due to the high water temperatures and the historical presence of the fish parasite *Dermocystidium* that has caused substantial mortalities in past years.

- Hatchery mating protocols willbe applied to reduce the risk of directed or unintentional selection of traits that could negatively affect the diversity of the listed population, and that will maximize the representation of each individual adult in the propagated population through: use of all males, including jacks, collected randomly from broodstock retained for spawning; spawning of eggs in three- or four-fish pools; spawning of each male in one-fish units (no pooling); and fertilization using a "modified factorial" mating design, where each bucket of pooled eggs is split into three to four aliquots, and each aliquot of eggs is fertilized with sperm from one male.

Lower Elwha Fish Hatchery Native Steelhead Program

The steelhead hatchery program will be sustained initially through the collection of broodstock from redds created by naturally spawning steelhead, and later from adult returns of late-returning winter run steelhead to the river. All broodstock retained for captive broodstock will be ascertained through genetic sampling to be part of the listed native steelhead population (LEKT 2012a). Over the proposed span of operation considered in this opinion (the preservation and restoration phases), broodstock will continue to be collected only from the Elwha River. The last collections of eggs to create captive broodstock occurred in 2011, and no additional redd removal actions are proposed. The last captive brood spawn will occur in 2015, and juvenile hatchery fish production after 2015 will rely entirely on collection and spawning of adult returns to the river. As the primary fish release strategy, juvenile fish that were the progeny of captive brood or adults collected from the river will be released directly from Lower Elwha Fish Hatchery (RM 1.3) as two-year old smolts (LEKT 2012a). As a secondary strategy during the preservation phase, hatchery-origin adult fish surplus to broodstock needs will be collected and transported for release upstream of the dam sites into habitat unaffected by stored sediment releases to allow the fish to spawn naturally. Spontaneous recolonization of upper watershed areas by steelhead will supplant adult fish transport and release as the secondary strategy during the recolonization phase, but upstream release of collected adults will continue, based on the viability status of the Elwha River steelhead population.

Based on currently available scientific information, the hatchery program will likely result in some hatchery-induced selection risks to the steelhead population remaining in the Elwha River. Some degree of effects associated with this hazard will likely be unavoidable, given that not all adult fish and families of aggregate hatchery- and wild-origin fish returning to the Elwha River each year were used to found the captive broodstock program, nor would all returning fish be collected and retained as broodstock when returning as adults. Hatchery-induced selection effects will also likely result, given the relatively high degree of hatchery intervention associated with the proposed supportive breeding actions (i.e., captive broodstock rearing). Rearing of fish for two years in the hatchery prior to their release would confer further selection risks as the fish are propagated for an extended period, and for a substantial proportion of their total life spans, in an artificial rather than a natural setting. Hatchery-origin steelhead adults transported and released to spawn naturally as the secondary supportive breeding action would have a low risk of further hatchery-induced selection because the spawning fish and their progeny would be exposed to selective pressures entirely in the natural, rather than the hatchery, environment.

In its most recent review of the Elwha River HGMPs, the HSRG repeated the opinion that prolonged hatchery influence may lead to the loss of fitness of natural populations, potentially resulting in reduced or delayed restoration (HSRG 2012). The HSRG also found that the strategies described for using hatchery production to preserve the genetic lineage of the native steelhead population are generally accepted as being appropriate for this purpose (HSRG 2012). HSRG recommendations regarding PHOS and PNI requirements for managing hatchery-origin steelhead contribution to spawning were not included in their most recent review of the program for operation during the preservation and restoration phases. Rather, these metrics were included for program operation only during the local adaptation and “full restoration” phases for fish restoration in the Elwha River. It is assumed that, like for Chinook salmon, the HSRG found that, given current and near term future steelhead stock status and habitat productivity conditions, that hatchery intervention would not lead to genetic risks that were so substantial as to offset demographic benefits during the preservation and recolonization phases. The EMG (EMG 2012) concluded that it will be unnecessary for the proposed Lower Elwha Fish Hatchery program to meet percent hatchery-origin fish spawner contribution (i.e., PHOS and PNI) goals during the early stages of restoration. Like Chinook salmon, they recommended that no stated PNI goals be set for the preservation and recolonization phases for steelhead (EWG 2012). This recommendation was based on the conclusion that the current stock composition will largely be maintained by the hatchery program and hatchery returns will far exceed natural-origin returns for steelhead until the prospects for survival improve. The EMG noted that the expected high turbidity levels resulted in NMFS requirements in the dam deconstruction consultation for broodstock collection at levels that would fully seed the LEKT steelhead supportive breeding program during the period of inhospitable, high turbidity to ensure the Elwha River native steelhead population is preserved (NMFS 2012a).

Genetic risk management measures, consistent with measures described in NMFS (2012b), are described in the LEKT steelhead HGMP to reduce the risk of intentional or unintentional hatchery-induced selection and biased sampling effects on Elwha steelhead population diversity over the preservation and recolonization phases of restoration (from LEKT 2012a):

- All broodstock used to sustain the proposed steelhead program will be genotyped and determined to be of native Elwha River, late-returning, winter-run steelhead lineage.

- Broodstock will be grown to adult size from eggs/fry originally collected from native steelhead redds (2005-2011), and from the run-at-large adult steelhead return to the Elwha River (post 2013). Out-of-basin strays from other steelhead populations will not be knowingly spawned or incorporated into the gene pool.

- Hatchery selection and biased sampling risks will be reduced through cessation of redd sampling after the 2011 collection year, and final spawning of the last brood year of captive broodstock steelhead in 2015. The highest level of hatchery intervention (captive broodstock rearing and spawning) would be terminated and replaced by a smolt release-based supplementation effort, resulting in reduced genetic diversity and fitness loss risks to the target steelhead population.

- Subsequent to 2012, hatchery-origin adult steelhead returning as a result of smolt releases will be used for hatchery broodstock. The inclusion as broodstock of the progeny of captive broodstock fish that were exposed to natural selective pressures and survived in the wild to return as adults would reduce hatchery-induced selection risks relative to previous, all captive brood-origin groups.

- Broodstock will be collected randomly across the breadth of the adult native steelhead return timing, and representative of the age class distribution and sex ratio for the species, from the combined number of fish collected at the Lower Elwha Fish Hatchery, the Elwha Channel Hatchery weir, and from the mainstem river weir and traps. These measures would reduce risks of hatchery-induced selection effects on the propagated population.

- In-river activities implemented to collect broodstock that would harm naturally spawning steelhead productivity, and potentially natural population diversity, will be minimized to reduce negative impacts on actively spawning fish and redds. The collection of eggs and/or fry from redds created by naturally spawning steelhead ended after the 2011 collection year and further redd disturbance will not occur.

- The cessation of egg collections from redds as part of broodstock collection after 2011 for the proposed program will substantially reduce the risk of biased sampling that could lead to hatchery-induced selection. The risk that only a subset of the total number of families would be included in the propagated population, and therefore unnaturally amplified in subsequent adult return abundances and proportions, will be reduced.

- During the preservation and recolonization phases, captive-reared adult fish, returning adult native stock hatchery-origin steelhead, and returning adult native stock natural-origin steelhead will be collected from the run-at-large for spawning at the hatcheries and through operation of the mainstem weir. Continuous incorporation of naturally produced steelhead will help reduce the risk of genetic divergence between the propagated and natural-origin components of the native steelhead population, and reduce the risk of hatchery-induced selection effects.

- During the recolonization phase, the proportion of hatchery-origin adult fish used for spawning and escaping to spawn naturally will be, managed depending on the abundance of natural-origin fish returns. One tool that will be used to manage/cull hatchery returns will be selective harvest.This will reduce the risk that fish derived from hatchery production would drive diversity of the propagated and naturally spawning populations.

- Potential loss of genetic diversity in the native steelhead population under propagation will be reduced by selecting mating pairs using pedigree analysis of all spawners each year. This will ensure that relatives are not crossed and that diversity of each year's gene pool is maximized, reducing hatchery-induced selection risks.

- Mating protocols developed in partnership with NWIFC geneticists will be applied to reduce the risk of directed or unintentional selection of traits that could negatively affect the diversity of the listed steelhead population (e.g., full- or half-sibling matings), and that will maximize the representation of each individual adult in the propagated population. These protocols will include:

    - use in spawning of all mature fish collected randomly from broodstock on any given day;
    - for captive broodstock-origin fish, scanning of all ovulating females to determine PIT tag identity and to identify appropriate mates;
    - mating of each female with three males;
    - prevention of matings between half- or full-siblings;
    - mating of males to females that are from different families; and,
    - individual spawning of each female and male in one-fish units (no pooling) and fertilization using a "modified factorial" mating design, where each female's eggs are split into three aliquots, and each aliquot of eggs is fertilized with sperm from one of the three males.

- As natural-origin steelhead spawn in the restored river, their progeny (as returning adult fish) would be integrated into the hatchery program at appropriate levels while ensuring that the naturally produced component of the population continues to expand into available habitat. Appropriate tagging and monitoring techniques would help ensure the success of this effort.

2.4.2.1.5. *Ecological Interaction Effects*

2.4.2.1.5.1. Competition

Competition occurs when the demand for a resource by two or more organisms exceeds the available supply. If the resource in question (e.g., food or space) is present in such abundance that it is not limiting, then competition is not occurring, even if both species are using the same resource. Adverse impacts of competition may result from direct interactions, whereby a hatchery-origin fish interferes with the accessibility to limited resources by naturally produced fish, or through indirect means, as when utilization of a limited resource by hatchery fish reduces the amount available for naturally produced fish (SIWG 1984). "Releasing non-indigenous or artificially propagated species into a listed species' habitat or where they may access the habitat of listed species" may harm listed species and therefore constitutes a "take" under the ESA (NMFS 1999a). Specific hazards associated with adverse competitive impacts of hatchery salmonids on listed naturally produced salmonids may include food resource competition, competition for juvenile rearing sites, and, to a lesser extent, competition for spawning sites (NMFS 2012b). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (SIWG 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at "high risk" due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

Factors influencing the risk of competition posed to juvenile natural-origin salmonids by juvenile salmonids released from hatcheries are: whether competition is intra- or interspecific; the duration of freshwater cohabitation of hatchery and natural-origin fish; relative body sizes between the two groups; prior residence of shared habitat; environmentally induced developmental differences; and fish density in shared habitat (this and following from Tartara and Berejikian 2012). Intraspecific competition would be expected to be greater than interspecific because of greater niche overlap between conspecific hatchery and natural-origin fish. Competition would be expected to increase with prolonged freshwater occurrence overlap between hatchery- and natural-origin salmon and steelhead. Although newly released hatchery-origin smolts are commonly larger than natural-origin fish, and larger fish have usually been found to be superior competitors, natural-origin fish have the competitive advantage of prior residence when defending territories and resources in shared natural freshwater habitat. Tartara and Berejikian (2012) further reported that hatchery-induced developmental differences from co-occurring natural-origin fish life stages are variable and can favor both hatchery- and natural-origin fish. They concluded that although all of the above factors may influence competitive interactions, fish density of the composite population (natural-origin plus hatchery-origin fish) in relation to habitat carrying capacity likely exerts the greatest influence.

Newly released seaward migrating hatchery smolts may compete with naturally produced fish for food and space in areas where they interact during downstream migration. Naturally produced fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, of equal or greater size, and (if hatchery fish are released as non-migrants) the hatchery fish have taken up residency before naturally produced fry emerge from redds. Release of large numbers of hatchery pre-smolts in a small area is believed to have greater potential for competitive impacts because of the extended period of interaction between hatchery fish and natural fish. In particular, hatchery programs that release fry and non-migrant fingerlings produce fish that compete for food and space with naturally produced salmonids for longer durations, if the hatchery fish are planted within, or disperse into, areas where naturally produced fish are present. A negative change in growth and condition of naturally produced fish through a change in their diet or feeding habits could occur following the release of hatchery salmonids. Any competitive impacts likely diminish as hatchery-produced fish disperse, but resource competition may continue to occur at some unknown, but lower level as natural-origin juvenile salmon and any commingled hatchery juveniles emigrate seaward.

Hatchery fish might alter naturally produced salmon behavioral patterns and habitat use in areas where they interact, making them more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter naturally produced salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Steward and Bjornn 1990; Hillman and Mullan 1989). In a review of the potential adverse impacts of hatchery releases on naturally produced salmonids, Steward and Bjornn (1990) indicated that it was indeterminate from the literature whether naturally produced parr face statistically significant risk of displacement by introduced hatchery fish, as a wide range of outcomes from hatchery-naturally produced fish interactions has been reported. The potential for negative impacts on the behavior, and hence survival, of naturally produced fish as a result of hatchery fish releases depends on the degree of spatial and temporal overlap between hatchery and naturally produced fish. The relative size of affected naturally produced fish, when compared to hatchery fish, as well as the abundance of hatchery fish encountered, also will determine the degree to which naturally produced fish are displaced (Steward and Bjornn 1990). Actual impacts on naturally produced fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

En masse hatchery salmon smolt releases may cause displacement of rearing naturally produced juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration (Pearsons et al. 1994). Pearsons et al. (1994) reported small-scale displacement of juvenile naturally produced rainbow trout from discrete sections of streams by hatchery steelhead released into an upper Yakima River tributary. The authors found that small-scale displacements and agonistic interactions observed between hatchery steelhead and naturally produced juvenile trout were most likely a result of the hatchery steelhead being larger than the juvenile trout and not something inherently different about hatchery fish. However, they noted that these behavioral interactions between hatchery-reared steelhead and juvenile trout did not have a statistically significant adverse effect on the overall abundance of the trout populations examined.

As noted earlier, the risk of competition between hatchery and naturally produced salmonids in freshwater may potentially be a high risk for coho salmon, Chinook salmon, and steelhead, and because of fish size at migration, and migration timing and behavior traits for the species, the risk of competition with hatchery fish for pink, chum, and sockeye salmon is low. Juvenile coho salmon are apparently dominant in agonistic encounters with juveniles of other stream-rearing salmonid species, including Chinook salmon, steelhead, and cutthroat trout (*O. clarki*), and with wild-origin coho salmon (e.g., Stein et al. 1972; Allee 1974; Swain and Riddell 1990; Taylor 1991) when placed in the same test habitat. However, there are substantial differences in habitat preferences between older juveniles of the three species, in particular between coho salmon and steelhead. Age-one and older steelhead prefer steeper gradient streams and riffle habitat, coho favor lower gradient streams and pool habitat. Chinook salmon also have different habitat preferences than coho salmon (Nilsson 1967; Lister and Genoe 1970; Taylor 1991). Along with the habitat differences exhibited by coho salmon and steelhead, they also showed differences in foraging behavior. Peterson (1966) and Johnston (1967) reported that juvenile coho salmon are surface oriented and feed primarily on drifting and flying insects, while steelhead are bottom oriented and feed largely on benthic insects. A net result of these intrinsic habitat preference and feeding behavioral differences is that the incidence of competitive interactions among coho and Chinook salmon, and steelhead in natural streams is much lower than interactions between members of the same species (intraspecific competition).

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

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990; California HSRG 2012).
- Operating hatcheries such that hatchery fish are reared to sufficient size that smoltification occurs in nearly the entire population (Bugert et al. 1992).
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing naturally produced juveniles.
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and timing if substantial competition with naturally rearing juveniles is documented.

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

For competition between species to occur, there must be substantial levels of spatial and temporal overlap and limited resources. With respect to spatial overlap, the current distribution of anadromous Elwha River salmonid species has until recently been constrained to the lower 5 miles of the Elwha River watershed including the estuary. These areas, and the approximately 8 miles of mainstem and tributary areas downstream of Glines Canyon Dam, are presently the only locations where spawning, incubation, rearing and migration of listed Chinook salmon, steelhead, and eulachon occur. The available freshwater area, and thus spawning and rearing areas, and potential food sources, supporting these salmonid life history segments will be expanded to include up to 90 miles (depending on the migration capabilities and behavior of each species – Pess et al 2008) of habitat after the Glines Canyon Dam site becomes passable to anadromous fish in 2013. The two hatchery locations where all juvenile salmon and steelhead releases will occur are at RM 3.5 and 1.3. Prior to dam removal and restoration of upstream fish access, all natural-origin fish will be confined to the lowest 5 miles of the Elwha River, and hatchery fish releases at RM 3.5 and 1.3 may lead to spatial overlap and potential competition. Post-dam removal, natural-origin fish present in the lower river may still interact with newly released hatchery fish. Natural origin fish produced above the dam sites and rearing in upstream areas will have a low likelihood for co-occuring and interacting with hatchery-origin juveniles because all hatchery-origin fish would be released on-station and no outplanting into upstream locations is proposed where a substantial proportion of total natural fish production in the watershed will occur. Partitioning of zones used by hatchery smolts and natural-origin Chinook salmon juveniles in the Elwha River estuary (as per Levings et al. 1986) would reduce spatial overlap and competitive interactions between the groups.

The degree to which natural- and hatchery-origin juvenile salmon and steelhead that share the same river areas will interact, potentially leading to competition effects, also depends on the opportunity for temporal overlap between the two groups (Table 17). With regards to effects on listed Chinook salmon, the majority of hatchery-origin Chinook salmon produced through the Elwha Channel Hatchery program willbe released as sub-yearling smolts in June, after the majority of juvenile natural-origin ocean-type Chinook salmon have emigrated seaward (Figure 4). Temporal overlap and the opportunity for substantial competition effects from this hatchery release type is not expected. Yearling Chinook salmon from the hatchery program will be released in April, and temporal overlap with natural-origin Chinook salmon present in the lower river and estuary is likely (Wunderlich and Dilley 1990). The disparity in individual size between hatchery yearlings and "0" age natural-origin Chinook salmon would make diet overlap, and food resource competition unlikely. Hatchery 2+ steelhead and yearling coho salmon releases from Lower Elwha Fish Hatchery would be delayed until mid-May each year (LEKT 2012a; 2012b) as a measure to minimize interactions with, and competition risks to, the majority of rearing and emigrating natural-origin Chinook salmon present in the lower watershed (Table 17). Fall chum and pink salmon fry would be released from Lower Elwha Fish Hatchery during the natural-origin fish emigration periods for the two species in late February through April for chum salmon and March through April for pink salmon. Because of their release timing, fall chum and pink salmon fry could co-occur with natural-origin Chinook salmon juveniles, but competition between the species would be unlikely due to differences in food preference (SIWG 1984). Also, the hatchery-origin fall chum and pink salmon would emigrate quickly seaward from their site of release at RM 1.3, and temporal overlap with Chinook salmon in the river where competitive interactions could occur would be of very short duration. Hatchery chum and pink salmon are expected to leave the river and enter salt-water only hours after their release.

Natural-origin steelhead juveniles would be present in the lower river during the hatchery fish release period as rearing parr and as rearing and emigrating smolts (2+ or 3+ fish). Tthese life stages may be vulnerable to competition with co-occurring hatchery-origin Chinook salmon, steelhead, and coho salmon for food and space in waters adjacent to and downstream of, the hatchery release sites. Young-of-the-year steelhead fry produced naturally in the lower river

Table 17. Comparative individual sizes and freshwater occurrence timings for rearing and/or emigrating natural-origin salmon and steelhead juveniles by species and life stage, and hatchery-origin smolts proposed for release from Elwha River hatchery programs.

Species/Origin	***Life Stage***	***Individual Size (mm fl avg. and range)***	***Occurrence or Release Timing***
Chinook salmon (wild)	Fry	*40 (34-59)*	*December-April*
Chinook salmon (wild)	Parr	*75 (57-92)*	*late May-July*
Chinook salmon (wild)	Yearling	*120 (92-154)*	*late March-May*
Chinook salmon	Sub-yearling	*80 (57-86)*	*June*
Chinook salmon	Yearling	*155 (155-196)*	*April*
Steelhead (wild)	Fry	*60 (23-100)*	*June-Oct.*
Steelhead (wild)	Parr	*96 (65-131)*	*Oct.- mid May*
Steelhead (wild)	Smolt	*165 (109-215)*	*late April-June*
Steelhead (hatchery)	Yearling	*206 (180-230)*	*mid May*
Coho (wild)	Fry	*30 (29-36)*	*March*
Coho (wild)	Parr	*37-74*	*April-April*
Coho (wild)	Yearling	*107 (74-190)*	*Late April-May*
Coho (hatchery)	Yearling	*140 (131-156)*	*mid May*
Chum (wild)	Fry	*38 (33-50)*	*February-May*
Chum (hatchery)	Fed fry	*50 (42-52)*	*late-February-April*
Pink (wild)	Fry	*34 (32-43)*	*March-April*
Pink (hatchery)	Fed fry	*50 (40-52)*	*March-April*
Sockeye (wild)	Fry	*28 (25-31)*	*April-May*
Sockeye (wild)	Lake phase	*32-119*	*June-March*
Sockeye (wild)	Smolt	*125 (120-129)*	*March-April*
Eulachon	Adult	*166, 180 (125-250)*	*February-April*

- Wild Chinook salmon data from Beamer et al. 2005 (parr and yearling data) and WDFW juvenile out-migrant trapping reports (Seiler et al 2000; 2003; 2004; Volkhardt et al., 2005, 2006a; Kinsel et al., 2007).
- Wild steelhead individual size data and occurrence estimates from Shapovalov and Taft (1954) and WDFW juvenile out-migrant trapping reports (Volkhardt et al., 2005b, 2006, Kinsel et al., 2007).
- Wild coho data for Green River from Topping et al. 2008 (smolts); Beachum and Murray 1990 and Sandecock (1991) (fry); parr size range extrapolated from smolt and fry data considering year-round residence.
- Wild chum data from Volkhardt et al. 2006 (Green River fall-run), and Tynan 2007 (summer-run).
- Wild pink salmon data from Topping et el 2008 (Dungeness Pink salmon).
- Wild sockeye salmon data from Burgner (1991) for Lake Washington sockeye (predominantly 3-1 fish). Parr size range extrapolated from smolt and fry data considering year-round residence.
- Average individual size for female and male eulachon collected in the Elwha River in 2005 from Table A-7 in Gustafson et al. 2010.
- Hatchery-origin fish release size and timing data are average individual fish size and standard release timing targets applied for hatchery salmon and steelhead production in Puget Sound from Elwha River Basin salmon and steelhead HGMPs and from WDFW and PNPTT 2000.

would emerge too late in the season to interact with newly released hatchery-origin fish, so competition risks for this steelhead life stage would be unsubstantial.

The co-managers have included hatchery management measures in the HGMPs that are expected to reduce the potential for competition between hatchery and natural-origin salmon and steelhead and eulachon:

- As the primary release strategy for fish in the supportive breeding program, all chum and pink salmon fry, sub-yearling Chinook salmon, 2+ steelhead, and yearling Chinook salmon and coho salmon will be released on-station at RM 1.3 and 3.5 in a physiological condition ready for transition to seawater. The HSRG concluded that the best strategy for avoiding negative ecological interactions among juveniles, including competition, would be to outplant only adults upstream of the dam sites, and juveniles directly from the hatchery (HSRG 2012). This is so close to the estuary that migration ready hatchery smolts are expected to spend only hours or at best days in the river and this will substantially limit or avoid any competition in the river between hatchery and natural-origin fish. The practice of releasing only actively migrating smolts that would exit freshwater rapidly would reduce the duration of interaction with natural-origin Chinook salmon, steelhead, or eulachon in the lower river that are of a life stage vulnerable to competition for food or space;
- The secondary release strategy during the preservation phase, and tertiary strategy (behind spontaneous upstream escapement) during the recolonization phase, would be the collection and subsequent release of adult fish, surplus to hatchery broodstock needs, into unaffected areas above the dam sites. Relative to outplanting juvenile fish, this measure would avoid negative ecological interactions among juveniles, including competition, in upstream areas.
- Steelhead 2+ and coho salmon yearling smolts that do not volitionally leave the hatchery will be removed from holding and acclimation sites and disposed of to limit residualism and the potential for competition between hatchery and natural-origin fish.
- There will be few natural-origin fish of any species in the lower Elwha River that would serve as prey during the preservation and recolonization phases when and where the hatchery programs are proposed for juvenile fish release due to the expected adverse effects of the release of stored sediments behind the dams on natural fish survival and productivity.
- Eulachon juveniles are not likely to be affected via competition with juvenile hatchery fish since they have not been observed in the lower Elwha River and no spawning or resultant juvenile fish presence has been documented;
- Eulachon adults are unlikely to be affected by hatchery-origin fish competition for food and space because fish collected in the Elwha River have been gravid fish that are not actively feeding. Also, the late spring release timings for hatchery-origin fish preclude any temporal overlap between the species; and,
- If natural population smolt outmigration timing, determined by juvenile outmigrant monitoring in the mainstem or tributaries, reveals an overlap with hatchery fish releases,

the alternate release timings or other mitigation measures will be considered to minimize interactions.

2.4.2.1.5.2. Predation

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

SIWG (1984) rated most risks associated with predation between anadromous salmonid species as unknown, because, although there can be spatial and temporal overlap between hatchery and naturally produced species, there was relatively little literature documentation of predation interactions in either freshwater or marine areas. Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to naturally produced fish (SIWG 1984). Some reports suggest that hatchery fish can prey on fish that are ½ their length (HSRG 2002a; Pearsons and Fritts 1999), but other studies have concluded that salmonid predators prefer smaller fish and are generally thought to prey on fish 1/3 or less their length (Horner 1978; Hillman and Mullan 1989; Beauchamp 1990; Cannamela 1992; CBFWA 1996). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Sosiak et al. 1979; Bachman 1984; Olla et al. 1998).

Due to their location, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation by hatchery released fish. Their vulnerability is believed to be greatest as they emerge from the gravel and decreases somewhat as they move into shallow, shoreline areas (USFWS 1994). Emigration out of hatchery release areas and foraging inefficiency of newly released hatchery smolts may reduce the degree of predation on salmonid fry (USFWS 1994).

Although considered an “unknown” risk by SIWG (1984), data from hatchery salmonid migration studies on the Lewis River, Washington (Hawkins and Tipping 1998), provide evidence of hatchery coho salmon yearling predation on salmonid fry in freshwater. Other researchers have reported that newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook salmon and steelhead, and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1985; Hawkins and Tipping 1999; Pearsons and Fritts 1999). The WDFW Lewis River study revealed low levels of hatchery steelhead smolt predation on salmonids. In a sample of 153 out-migrating hatchery-origin steelhead smolts, 12 fish (7.8 percent) were observed to have consumed juvenile salmonids (S. Hawkins, WDFW, personal communication, July 1997). The juvenile salmonids contained in the steelhead stomachs appeared to be Chinook salmon fry.

Sharpe et al. (2008) studied juvenile steelhead predation on Chinook salmon fry using stomach content analysis in the Deschutes, Green, Coweeman and Kalama rivers upstream of and within known juvenile fall Chinook salmon rearing areas. They found that the incidence of predation by hatchery steelhead on fall Chinook salmon was uniformly low across all hatchery steelhead release locations tested. Of the 6,029 hatchery steelhead examined, 10 fall Chinook salmon fry had recently been consumed (0.002 fry/stomach). Hatchery steelhead timing of release protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook salmon fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Sampling through the Lewis River study indicated that no emergent wild-produced steelhead or trout fry (30-33 mm fl) were present during the first two months of sampling, though that is not surprising since wild steelhead in the system spawn primarily in April and May.

Available information regarding predation on smaller Chinook salmon varies widely. Steward and Bjornn (1990) referenced a report from California that estimated, through indirect calculations, rather than actual field sampling methods, the potential for substantial predation impacts by hatchery yearling Chinook salmon on naturally produced Chinook salmon and steelhead fry. They also reference a study in British Columbia that reported no evidence of predation by hatchery Chinook salmon smolts on emigrating naturally produced Chinook salmon fry in the Nicola River. In addition, Bakkala (1970, quoting Hunter (1959) and Pritchard (1936)) reported that young coho salmon in some British Columbia streams averaged two to four chum salmon fry per stomach sampled.

Hatchery impacts from predation can be minimized by:

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.
- Releasing hatchery smolts in lower river areas near river mouths, and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism (see previous discussion).

The risk of hatchery-origin smolt predation on natural-origin juvenile fish is dependent upon three factors: (1) the hatchery fish and their potential natural-origin prey must overlap temporally; (2) the hatchery fish and their prey must overlap spatially; and, (3) the prey should be less than 1/3 the length of the predatory fish.

Table 17 compares the relative size and the spatial and temporal distribution of natural-origin juvenile Chinook salmon and steelhead, and hatchery-origin juveniles. Considering natural fish occurrence and hatchery-origin fish release timing into the lower Elwha River, where predator-prey interactions would potentially occur, the hatchery-origin species and life stages that would overlap with listed natural-origin juvenile Chinook salmon and steelhead would be sub-yearling and yearling Chinook salmon, 2+ steelhead, coho yearlings and fall chum and pink salmon fry. Although the spatial and termporal distribution of eulachon in the Elwha River is largely unknown, these same hatchery-origin salmon and steelhead s may be assumed to overlap spatially and temporally with listed eulachon.

Considering the size and growth information in
Table 17, Chinook salmon yearlings released in April would be large enough to prey on any juvenile Chinook salmon less than 50 mm (fl). Hatchery yearling Chinook salmon would not encounter juvenile natural-origin steelhead in April that would be small enough to prey upon. Although of similar size, hatchery-origin 2+ steelhead and coho yearlings are released in mid-May when any co-occurring natural-origin Chinook salmon subyearlings and steelhead parr are be too large to prey upon. Subyearling Chinook salmon, fall chum salmon, and pink salmon that will be released through the proposed hatchery programs are too small to consume any natural-origin Chinook salmon and steelhead and would not be a risk factor for predation.

Although the diet of hatchery-origin Chinook salmon yearling smolts produced by Elwha River Channel Hatchery has not typically been found to include a substantial proportion of sub-yearling Chinook salmon or juvenile steelhead, their size differential indicates the potential for predation (Peters 1996). However, the potential for predation by hatchery-origin yearling Chinook salmon, and other hatchery-origin fish that would be released as yearling or larger fish, would be minimized by the practice of releasing all hatchery fish as migration-ready smolts directly from the hatcheries, which are located in the lower portion of the river (RM 3.5 and 1.3). Hatchery smolts on their way to the ocean would typically co-occur very briefly in the lower Elwha River with natural-origin fish. For example, coho salmon smolts released from Lower Elwha Fish Hatchery have been shown to move quickly downstream to the mouth of the Elwha River, where they directly enter the Strait of Juan de Fuca, or reside in estuarine beach lakes (RM 0.1) for a brief period prior entering the Strait (Peters, 1996 cited in LEKT 2012b). Surveys on the Elwha River during the hatchery coho salmon release period indicate that following entry into the Elwha River, smolts do not move back upstream (Peters 1996). Stomach content analyses of salmonids, including hatchery-origin steelhead and coho salmon, sampled near the mouth of the Elwha River in 1996, 2006, and 2007 showed no sign of piscivorous behavior (Peters 1996; Duda et al. 2011). Further monitoring near the river mouth, side channel areas, and estuary ponds would assist in verifying these findings. The juvenile life stage of eulachon may not be of concern as a prey item for hatchery-origin fish, as only adult eulachon have been observed in the lower Elwha River, and no spawning or resultant juvenile fish presence have been documented. The relatively large size of eulachon (Table 17) precludes predation on the species in the action area by any juvenile fish that would be released from the hatcheries.

NMFS does not expect that predation by newly released hatchery-origin salmon and steelhead juveniles would pose a substantial risk to listed natural-origin fish populations in the lower Elwha River downstream from the hatchery releases sites. The risk of predation will be adequately minimized through application of the measures described in the HGMPs. Those measures and their rationale are:

- As the primary supportive breeding strategy, all hatchery-origin juveniles would be released on-station into the lower river at RM 1.3 or 3.5. The lower river release locations limit the duration of hatchery fish presence in freshwater, reducing the duration of interaction with any natural-origin fish of a size vulnerable to predation. The secondary artificial production strategy proposed during the preservation and recolonization phases would be the upstream transport and release of adult fish above the dam sites.
- All yearling fish would be released from the hatcheries as actively migrating smolts that would exit freshwater rapidly. This smolt release practice would reduce the duration of interaction with any natural-origin fish of a size vulnerable to predation in the lower river;
- Steelhead 2+ and coho salmon yearling smolts that do not volitionally leave the hatchery at the times of their release will be removed from rearing units and disposed of to limit residualism and enhanced risks of predation associated with residualizing hatchery fish.
- There will be few natural-origin fish of any species in the lower Elwha River that would serve as prey during the preservation and recolonization phases when and where proposed juvenile fish releases would occur due to the adverse effects on natural-origin fish survival and productivity from the release of stored sediments behind the dams;
- Diet studies conducted in the Elwha River have indicated that newly released hatchery-origin yearling fish (Chinook, coho and steelhead) do not prey on fish; and,
- If naturally-produced smolt outmigration timing, determined by juvenile outmigrant monitoring in the mainstem or tributaries, suggests that proposed release timings for Chinook salmon, steelhead, and coho salmon from the hatcheries would result in harmful ecological interactions with listed natural-origin fish, alternate release timings or other mitigation measures will be developed to minimize such interactions.

2.4.2.1.6. *Harvest*

This category of hatchery-related risk includes effects on listed fish, both natural-origin and hatchery-origin, from fisheries managed for, or directed at, the harvest of hatchery-origin fish have been identified as one of the primary factors leading to the decline of many naturally produced salmonid stocks (Flagg et al. 1995; Myers et al. 1998). Depending on the characteristics of a fishery regime, the commercial and recreational pursuit of hatchery fish can lead to the harvest of naturally produced fish and hatchery fish used for conservation purposes, in excess of levels compatible with their survival and recovery (NRC 1996). Listed salmon and steelhead may be intercepted in mixed stock fisheries targeting predominantly returning hatchery fish or healthy natural populations (Mundy 1997). Fisheries can be managed for the aggregate return of hatchery and naturally produced fish, which can lead to higher than expected harvest of natural populations.

Over the past 20 years, harvest management practices have continually been adjusted and refined for the purpose of protecting listed species and these efforts have been largely successful. In the case of the Puget Sound Chinook salmon ESU, that includes the Elwha Chinook salmon population, NMFS has completed consultations on fisheries affecting this ESU and those effects are included in the environmental baseline of this opinion.

The need to reduce harvest impacts on weak salmon stocks as a result of regional and international fisheries management agreements and, later, the ESA-listing of natural-origin salmon and steelhead populations has led to substantial reductions in total allowable exploitation rates on nearly all species in mixed stock and terminal area fisheries. In many areas, fisheries important to the Puget Sound Tribes and the citizens of Washington have been closed entirely to protect natural-origin populations. For example, directed fisheries on Chinook salmon in the Elwha River have been closed for decades, and impacts in mixed stock fisheries harvesting Elwha Chinook salmon have been severely restricted (PSIT and WDFW 2010; NMFS 2011b) in response to the diminished abundance of the species resulting from habitat blockage and degradation. Managers account for total harvest mortality across all fisheries in Pacific Northwest (e.g., PFMC 2003; 2009) and international (Pacific Salmon Treaty, e.g., CTC 2008) forums. Since the first ESA listings, the primary focus of harvest management decisions has been to craft fishery management plans that harvest hatchery fish and fish from healthy natural popoulations and that do not jeopardize weak ones. For an in depth review of harvest management actions affecting Puget Sound salmon and steelhead see the Puget Sound co-managers' most recent harvest management plan for Chinook salmon (PSIT and WDFW 2010) and NMFS's evaluation and 4(d) determination regarding the plan (NMFS 2011b). The current approaches for harvest management have resulted in harvest no longer being considered one of the top five limiting factors for almost all of listed salmon species.

Rutter (1997) observed that the effects on listed populations from harvesting hatchery-produced fish can be reduced by certain management actions:

- Externally marking hatchery fish so that they can be differentiated from unmarked, natural fish.
- Conducting fisheries that can selectively harvest only hatchery-produced fish with naturally produced fish being released.
- Manage fisheries for the cumulative harvest rate from all fisheries to prevent over-harvest (Mundy 1997).
- Ensure that harvest rates are not increased because of a large return of hatchery fish by managing fisheries based on the abundance and status of co-occurring natural population(s).
- Promote terminal fisheries on hatchery fish so that returning adults can be harvested with little or no interception of naturally produced fish. Fisheries can occur near acclimation sites or in other areas where released hatchery fish have a tendency to concentrate, which reduces the catch of naturally produced fish.
- Reduce or eliminating the number of fish released from hatcheries if fisheries targeting hatchery fish cannot be managed compatible with the survival and recovery of listed fish.

Fisheries harvest impacts on listed Chinook salmon and steelhead resulting from, or associated with, the production of Elwha River hatchery-origin Chinook salmon (WDFW 2012), Chambers

Creek-linage steelhead (LEKT 2012a), and coho salmon (LEKT 2012b) were previously evaluated and authorized by NMFS through a separate ESA consultation (NMFS 2011b - Table 14), and are included in the environmental baseline of this opinion. This separate consultation evaluated the effects of the co-managers' Resource Management Plan (RMP) for all Puget Sound salmon fisheries potentially affecting listed Puget Sound Chinook salmon, pursuant to 50 CFR 223.209 (Tribal Rule) and the government-to government processes therein. NMFS determined under 50 CFR 223.203(b)(6) that implementing and enforcing the harvest RMP would not appreciably reduce the likelihood of survival and recovery of the Puget Sound Chinook salmon ESU (NMFS 2011b). Effects associated with LEKT fisheries for remaining adult returns of Chambers Creek-lineage steelhead, as a genetic risk reduction measure, are included within this previous authorization (NMFS 2011b).

Under the Elwha Channel Hatchery Chinook salmon HGMP, WDFW will mark, with an adipose fin clip and a cooded-wire-tag, 250,000 subyearling Chinook salmon beginning with releases in 2013. The purpose for marking these fish is to better understand the effects of ocean fisheries on Elwha River Chinook salmon (i.e., where and to what extent these fish are harvested in ocean fisheries). Only 10 percent of the subyearling production will be marked to gain this information so that fish produced through the program are not subject to unnecessary risk. After 2017, when the first results of this trial tagging experiment become available, including effects of the tagging on Chinook salmon escapement and hatchery broodstock needs, adipose tagging will be reaassesed. However, WDFW does propose to mark with an adipose fin clip all yearling Chinook salmon beginning no earlier than brood year 2014, and all subyearling Chinook salmon beginning no earlier than brood year 2016 (WDFW 2012). Adipose clipping of the entire release groups may be delayed if sediment levels in the river remain high, natural production is low, it is judged unlikely that broodstock management will be initiated with the adult return of the 2015 brood of subyearling Chinook, and analysis of CWT recoveries indicates a substantially higher mortality rate of clipped Chinook salmon in mark-selective fisheries than projected by the Fishery Regulation Assessment Model (FRAM) FRAM. Previously, only a very small proportion, and only in some years, have Chinook salmon produced by the program been released with a visibly identifiable mark. Under the 4(d) rule for listed Puget Sound Chinook salmon (70 FR 37160. June 28, 2005), hatchery-origin fish marked with an adipose fin clip are excluded from ESA section 9 take prohibitions and would not receive 4(d) rule protection. Under the rule, fish marked with an adipose fin clip are not protected to allow for the harvest of fish not necessary for the conservation of the ESU.

To estimate harvest impacts that would result from adipose fin clipping Elwha Hatchery Chinook salmon, WDFW uses the FRAM to estimate and compare total fisheries exploitation rates for Elwha Chinook salmon marked with an adipose fin clip and an unmarked hatchery population, assuming fishing regimes similar to recent years (2011 and 2012) (WDFW 2012). The FRAM predicted an average annual exploitation rate for unmarked Elwha Chinook salmon of 50.1%, resulting in an estimated adult escapement abundance of 1,738 fish. With a 100% adipose fin-clipped hatchery population, the FRAM run under the same fisheries regime assumptions, predicted a total exploitation rate of 51.5% with a river escapement of 1,690 fish. WDFW therefore estimates that there would be a reduction in Chinook salmon escapement to the Elwha River, relative to baseline conditions, of about 48 adult fish (or a 2.8% reduction in escapement) as a consequence of adipose fin clipping all Elwha hatchery-origin Chinook salmon.

Harvest impacts resulting from the production of fall chum salmon (LEKT 2012c) and pink salmon (LEKT and WDFW 2012) are not expected to result in any substantial harvest effects on listed fish species. Because of the extremely depressed abundance of the chum and pink salmon populations used as donor broodstock, the proposed programs would produce modest numbers of adult fish, with all resultant returns needed for spawning in the natural or hatchery environments during the preservation and recolonization phases. No fisheries targeting fall chum and pink salmon are planned that could potentially affect listed Chinook salmon and steelhead.

None of the proposed programs would lead to harvest impacts on eulachon in the Elwha River. Gear types used to harvest salmon and steelhead in any fisheries do not affect eulachon, as they are too small to be susceptible to harvest by net mesh sizes used in tribal fisheries. Any recreational salmon and steelhead fisheries would also not result in the incidental capture of eulachon, which are not susceptible to harvest through hook and line gear.

As mentioned previously, the LEKT is proposing to harvest hatchery steelhead that are surplus to conservation and rebuilding needs. A harvest plan was submitted to NMFS subsequent to NMFS' acceptance of the HGMPs and the drafting of this opinion (LEKT 2012d). The effects of the harvest plan on listed fish will be evaluated in greater detail in a separate ESA consultation, subject to the requirements of limit 7 of the 4(d) rule for Puget Sound steelhead (73 FR 55451. September 25, 2008). However, because the plan is connected to the abundance levels contemplated by the LEKT steelhead hatchery program, we consider its effects briefly. The planned harvest would be directed at hatchery steelhead adults produced by the LEKT program. The hatchery steelhead would be differentially marked to allow for their visual identification and differentiation from natural steelhead. Harvests would focus on hatchery steelhead surplus to conservation and recovery needs, returning through juvenile fish release abundance levels equivalent to those considered in this opinion. Therefore, because any potential harvest program will not target the natural-origin steelhead and will not remove any hatchery-origin steelhead needed to achieve the recovery goals, NMFS does not believe at this time that the harvest would result in any effects to listed species.

2.4.2.1.7. *Monitoring and Evaluation Methodology*

Monitoring and evaluation programs are necessary to determine the performance of hatchery programs. The Artificial Production Review (NPPC 1999) listed four criteria for evaluating both augmentation and mitigation programs:

1. Has the hatchery achieved its objectives?
2. Has the hatchery incurred costs to natural production?
3. Are there genetic impacts associated with the hatchery production?
4. Is the benefit greater than the cost?

Historically, hatchery performance was determined solely on the hatchery's ability to release fish (NPPC 1999); this was further expanded to include hatchery contribution to fisheries (e.g., Wallis 1964; Wahle and Vreeland 1978; Vreeland 1989). Past program-wide reviews of hatchery programs in the Northwest have indicated that monitoring and evaluation have not been adequate to determine if the hatchery objectives are being met (ISG 1996; NRC 1996; NFHRP

1994; HSRG 2002a). The lack of adequate monitoring and evaluation has resulted in the loss or absence of information that could have been used to adaptively manage hatchery programs (NRC 1996; HSRG 2012).

There are four factors relative to monitoring and evaluation requirements that NMFS considers in biological opinions for hatchery programs. First, validating whether actions and commitments analyzed in the opinion are in fact implemented (i.e., compliance monitoring). Second, evaluating whether the actions analyzed in the opinion perform as expected (i.e., performance monitoring). Third, filling information gaps or addressing critical uncertainties, and, fourth, tracking hatchery effects to assure that limits on incidental take impacts are not exceeded.

Monitoring and evaluation of the performance and effects of supportive breeding actions require sampling of naturally produced adults and juveniles in natural production areas. In the Elwha River watershed, naturally produced populations of ESA-listed Chinook salmon, steelhead, and eulachon may be affected by such sampling. NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (e.g., NMFS 2000; NMFS 2008), which have been incorporated as terms and conditions into recent section 10 and section 7 permits for research and enhancement activities (e.g., NMFS 2010a). Though necessary to monitor and evaluate impacts on listed populations from hatchery programs, monitoring and evaluation programs should be designed and coordinated with other plans (e.g., NMFS 2006a; NMFS 2012a) to maximize the data collection while minimizing take of listed fish.

Section 1.3.6 of this opinion describes hatchery-related monitoring and evaluation actions in the HGMPs that have not been previously evaluated for listed fish effects. As noted in that section, these actions would complement and/or augment the core monitoring actions identified in the EMG MAMP (EMG 2012) and implemented as part of the NPS consultation regarding dam deconstruction effects (Table 18).. These core monitoring and evaluation actions will be used to both assess listed Chinook salmon and steelhead population viability status during and after dam deconstruction, and hatchery program performance effects. Through its consultation with NPS, NMFS evaluated and authorized the listed fish take effects of the monitoring and evaluation actions identified in Table 18. Spawning ground surveys described in the HGMPs to assess the abundance (numbers of adults or redds), distribution, and origin (hatchery or natural) of salmon and steelhead escaping to spawn naturally are among the actions included and authorized in the previous NMFS consultation. Effects on listed species from foot, boat, and snorkel surveys, including disturbance of migrating/holding adult fish; disturbance and displacement from redds of naturally spawning fish; physical harm to the structure of redds; and, mortality of incubating eggs through redd trampling are authorized under NMFS (2012a). Listed eulachon would not be affected by the spawning ground survey and sampling actions, because no eulachon have been observed in the river during the summer, fall, and winter months when the salmon and steelhead-directed activities would occur.

For monitoring and evaluation actions and programs described in Table 8 and Table 9, effects on listed fish that would potentially result, specifically from implementation of the additional monitoring and evaluation actions described in HGMPs and not previously addressed as required in NMFS (2012a), are discussed below.

Table 18. Monitoring and evaluation actions required by NMFS through its ESA consultation with NPS to assess the viability status of Elwha River Chinook salmon and steelhead during and for a period after deconstruction of Elwha Dam and Glines Canyon Dam (NMFS 2012a).

Monitoring and Evaluation Action	Purpose	Cooperating Agencies
Spawning Ground Surveys (boat, foot, and snorkel)	Assess listed adult fish spawning escapement abundance and distribution	WDFW, LEKT, NPS, NMFS, USGS
Mainstem Resistance Board Weir Operation	Assess listed adult fish spawning escapement abundance upstream of RM 3.7	WDFW, USFWS, NMFS
Juvenile Fish Outmigrant Trap Operation	Determine productivity of naturally spawning fish upstream of dam sites	NMFS, LEKT, WDFW
DIDSON Operation	Assess adult salmon and steelhead spawning escapement abundance	NMFS, WDFW, USFWS
Aerial Spawning Ground Surveys	Assess adult fish spawning escapement abundance and distribution in the upper watershed	NPS, NMFS, USFWS, WDFW
Fish Health Surveys and Sampling	Adult fish sampling to identify fish disease pathogen status in wild fish.	USFWS
Fish Relocation	Upstream transport and release of adult salmon and steelhead to increase spawner escapement abundances in middle and upper river reaches	WDFW, LEKT
Fish tagging and tracking	Monitor and assess salmon and steelhead distribution	NMFS, NPS, USFWS, WDFW, and LEKT
Habitat and Ecosystem Status	Monitor/track habitat conditions in the watershed as they recover from dam deconstruction effects	USGS, NMFS, LEKT

Sampling (scale, tissue, mark/tag and/or otolith) of adults returning to the hatcheries and escaping to spawn naturally (usually carcasses) to assess fish species status and origin would lead to takes of listed Chinook salmon and steelhead. Maximum annual take levels could be derived by assuming all listed hatchery-origin Chinook salmon and steelhead escaping to the hatcheries and/or collected for use as broodstock would be sampled for tissues, scales, or marks/tags. Based on broodstock collection needs, up to 1,700 Chinook salmon and 500 steelhead would be affected. A subset of the total annual number carcasses from naturally spawning Chinook salmon and steelhead would be subject to sampling and take each year. Marking and/or tagging of all juvenile Chinook salmon and steelhead released through the hatchery programs to allow for assessment of hatchery program performance and effects would lead to takes of up to 2.9 million Chinook salmon and 175,000 native stock steelhead each year. Sampling of Chinook salmon and steelhead reared in the hatchery and prior to their release for fish health monitoring purposes would lead to the handling, injury and mortality of a subset (n = 60) of the total number of adult fish retained as broodstock and juvenile fish produced each year. The number of fish affected by fish health sampling would be de minim and is relative to the total number of salmon and steelhead proposed for release each year.

NMFS does not expect that monitoring and evaluation actions in the HGMPs would pose a substantial risk to the natural populations or to listed fish under propagation in the hatcheries. Risks under this hazard category would be partially ameliorated through application of the following measures implemented by LEKT and WDFW:

- All listed fish under propagation would be marked or tagged using standard procedures that would ensure that incidental injury and mortality levels for listed Chinook salmon and steelhead would remain low and within acceptable levels.
- The degree to which listed Chinook salmon and steelhead are safe-guarded while in the hatchery environment would be monitored through documentation of fish cultural techniques. The co-managers would document whether the programs are meeting objectives, including monitoring and evaluation actions, and to identify the need for adjustment to adequately safeguard the listed fish. Actions monitored and documented would be: broodstock collection and handling procedures, fish and egg condition at the time of spawning, fertilization procedures, incubation methods/densities, temperature unit records by developmental stage, egg shocking methods, fungus treatment methods for eggs; start feeding methods, rearing/pond loading densities, feeding schedules and rates; fish release locations and methods; and fish mortality levels by life stage;
- Monitoring and evaluation of listed fish under propagation and in the natural environment would be undertaken in a manner that does not result in unauthorized take; and,
- All listed fish monitored for fish health assessment purposes would be sampled consistent with co-manager Fish Health Policy, and procedures referenced in the policy, to minimize the proportion of the total rearing population exposed to handling and non-lethal and lethal sampling.

2.4.2.2. Benefits

In terms of species conservation and rebuilding, there are pros and cons, benefits and risks from direct or indirect involvement with hatcheries (Hard et al. 1992)). In the specific case of the Elwha, the benefits to listed Chinook salmon and steelhead in the action area that are expected to result from implementation of the actions described in Section 1.3 of this opinion are evaluated below. Subcategories of benefits identified in Table 16 are also considered. Hatchery programs for which there are no listed fish benefits, or for which benefits are identified in Table 16 as not likely to be measureable, are not evaluated any further.

2.4.2.2.1. *Abundance*

Many hatchery programs in the Pacific Northwest are operated to mitigate for natural-origin salmon and steelhead abundances that are diminished from historical levels due to fish habitat loss and degradation. Mitigation programs are implemented throughout the Puget Sound region and several have been operating for over 100 years. The programs, in general, are obligated - most often as a condition of Federal, state, or municipal water development project permits - to maintain cultural values and economies dependent on fish by functioning in place of blocked, degraded, or lost habitat areas that can no longer produce natural-origin fish at levels observed historically.

Mitigation hatchery programs are designed to sustain and enhance the total abundances of salmon and steelhead species, primarily for harvest in tribal ceremonial, subsistence and commercial fisheries, and in Washington State all-citizen recreational and commercial fisheries. The majority of these mitigation programs in Puget Sound are not designed to benefit natural-origin salmonid population viability or ESU status, instead serving primarily to meet cultural and socioeconomic needs. But in some instances, they also enable retention of a species in substantial numbers in a watershed where the species would be very low in abundance or absent, but for the hatchery program. These types of programs use the most effective and biologically acceptable means to circumvent the natural spawning, incubation, and freshwater rearing phases of the salmon life-cycle that limit natural-origin population abundance and productivity in watersheds lacking properly functioning habitat. Hatcheries in the Puget Sound region that are predominantly operated for fish loss mitigation purposes contribute substantially to the total annual adult abundance of most salmon species captured in fisheries and returning to freshwater areas (Table 19). The total abundance of Chinook salmon, a species listed as threatened in the Puget Sound region, is predominantly supported by hatchery production.

Chinook salmon and steelhead that would be produced as part of the proposed Elwha River supportive breeding actions are part of the listed Puget Sound Chinook salmon ESU and Puget Sound steelhead DPS, respectively. Hatchery programs can contain genetic resources reflecting the evolutionary legacy of the species (70 FR 37204, June 28, 2005). Contributions of adult hatchery-origin Chinook salmon and steelhead returning to the Elwha River resulting from implementation of the hatchery programs would increase the total abundance (i.e., genetic resources) – hatchery-origin plus natural-origin - of the listed populations. The total abundance of these listed species supported by hatcheries would be expected to be substantially greater than abundances produced by natural production alone during the initial (current) phases of restoration, when sediment and turbidity levels in the lower river will disrupt fish survival andproductivity. Under the worst case, Chinook salmon and steelhead abundance could approach zero for brood years adversely affected by inhospitable river turbidity and sediment conditions, considering current very low abundance levels for natural-origin fish components of both species prior to dam removal. Preservation of total species abundance during the preservation and recolonization phases would differ from the type of benefit potentially conferred to natural-origin fish abundance, which would affect population viability.

From Table 3 and Table 4, the total (hatchery- plus natural-origin) natural spawning escapement abundance triggers marking the interface between the preservation and recolonization phases for Chinook salmon and steelhead are 1,028 fish and 500 fish, respectively. Assuming continued on-station hatchery fish release levels, static first generation hatchery adult return levels (Tables 9 and 11), and a spontaneous and truck-planted hatchery fish natural spawning level of 524 Chinook salmon and 813 steelhead (see section 2.4.2.2.2 - Abundance), adult hatchery fish production would comprise 51% of the naturally spawning fish phase trigger for Chinook salmon and 163% of the steelhead. Each hatchery program will also produce a sufficient number of hatchery-origin Chinook salmon and steelhead to meet broodstock collection needs to sustain juvenile fish production levels – 1,700 Chinook salmon and 300 steelhead.

Table 19. Recent year average total adult salmon run size estimates and the proportion of total adult run sizes resulting from hatchery production in the Puget Sound region.

Species	Terminal Run-Size (Total Puget Sound catch + escapement)	Hatchery-origin Adult Terminal Run Size	Hatchery-origin Adult Percent of Total Terminal Run Size
Chinook salmon 1/	221,649	163,496	74
Steelhead 2/	Unavailable	Unavailable	Unavailable
Coho salmon 3/	960,006	447,285	47
Chum salmon 4/	1,866,594	534,145	29
Pink salmon 5/	1,755,989	24,255	1.4
Sockeye salmon 6/	337,767	101,330	30

1/ Data for 2000-2004 from WDFW 2005 Stock Strength Summaries (B. Sanford, WDFW, June, 2005).2/ Complete data for Puget Sound steelhead populations, in particular for summer steelhead and most hatchery populations that contribute to natural spawning, is unavailable.

3/ Puget Sound coho salmon run reconstruction data for 1999-2004 from J. Haymes, WDFW, July, 2005.

4/ Data for Puget Sound summer, fall, and winter chum salmon for 1998-2002 from WDFW chum salmon web-site - http://wdfw.wa.gov/fish/chum/chum-5e.htm

5/ Data for Puget Sound pink salmon for 1989-2003 from K. Adicks, WDFW, October 17, 2005.

6/ Estimated percent contribution of hatchery-origin sockeye salmon to the total Puget Sound return (Cedar River and Baker River) provided by Kyle Adicks, WDFW, October, 2005. Total adult return data from Baker Lake sockeye salmon trap counts and Ballard Lock fish counts for 2000-2004 accessed from WDFW sockeye salmon web-site - http://wdfw.wa.gov/fish/sockeye/index.htm.

The total natural spawning abundance triggers established for both species between the recolonization and local adaptation phases is based on natural-origin fish only. The above total abundance contribution estimates for the Chinook salmon and steelhead hatchery programs donot take into account returns from production of hatchery-origin Chinook salmon and steelhead that are trucked and released upstream or that escape upstream, without help, to spawn naturally. The supportive breeding programs are expected to be beneficial to the total abundance of the listed species during the initial phases of restoration and for meeting the first set of abundance triggers, but the track record of supportive breeding in producing natural-origin adult fish returns is unproven. Survival and productivity of the fish reintroduced into upper river areas newly accessible to the species, and subsequently rearing or migrating through recovering lowerriver and estuary habitats, are unknown.

2.4.2.2.2. *Population Viability*

In an evaluation of hatchery effects associated with implementation of its Hatchery Listing Policy (70 FR 37204, June 28, 2005), NMFS determined that fish produced through certain artificial propagation programs in the Puget Sound region may benefit particular viability parameters (McElhany et al. 2000) for specific populations included within listed salmon ESUs and DPSs (70 FR 37204. June 28, 2005). Hatchery-origin populations determined to be no more than moderately diverged from reference natural-origin populations in the watersheds where the hatchery-origin fish were released were determined to impart varying degrees of benefits to the abundance, diversity, and spatial structure of natural-origin salmon and steelhead populations. Chinook salmon that would be produced through the proposed Elwha Channel Hatchery program (WDFW 2012) and native stock steelhead that would be produced by the Lower Elwha Fish

Hatchery program (LEKT 2012a) are considered no more than moderately diverged from their associated natural-origin populations that served as donor broodstock for the programs (70 FR 37160; 76 FR 50448). The ESA-listed hatchery-origin fish produced by both programs may therefore potentially impart viability benefits to the natural-origin populations that they were designed to support (NMFS 2004a).

Abundance

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

The primary objective of Puget Sound Chinook salmon and steelhead hatchery programs directed at conservation is to bolster, in an accelerated manner, the abundance of critically depleted or at-risk populations, and also to preserve their genetic integrity. These types of programs are regarded as essential to the preservation and recovery of individual populations composing the Puget Sound salmon ESUs and steelhead DPS, particularly as the populations they benefit embody unique aspects of life history and genetic diversity (e.g., South Fork Nooksack Chinook salmon; White River winter-run steelhead). Conservation hatchery programs may accelerate recovery of a target population by increasing abundance in a shorter time period than may occur naturally (Waples 1999). These types of hatchery programs may also be used to create a genetic reserve for a population to prevent the loss of its unique traits due to natural or human-caused catastrophes. Hatchery releases may be used to seed or reseed salmonid abundance in suitable, but vacant, habitat once the habitat factors limiting such uses have been addressed (e.g., anadromous fish restoration upstream of the Elwha River dams). Supportive breeding through these programs may also be used to provide scientific information regarding the use of artificial propagation in conserving natural-origin fish populations.

Elwha Channel Hatchery Chinook salmon program

The Elwha Channel Hatchery Chinook salmon program will be implemented in support of the native Elwha Chinook salmon population (WDFW 2012). The program will provide a safety net for the native stock while habitat conditions initially erode, and then gradually improve to a state that would sustain natural-origin Chinook salmon survival and productivity. All fish produced by the hatchery program will be included with natural-origin Elwha Chinook salmon as part of the Puget Sound Chinook salmon ESU listed under the ESA. Assuming annual on-station hatchery production of 2.5 million subyearlings, total releases of 400,000 yearlings (on-station and into Morse Creek), survival rates to adult return of 0.5% for subyearlings and 1.0% for yearlings (WDFW goal levels from Fuss and Ashbrook 1995), and a marine area fisheries harvest rate of 25% (recent year estimate from L. LaVoy, NMFS, pers. comm. May 2012), the proposed program could potentially lead to the return of 12,375 adult Chinook salmon to the Elwha River and Morse Creek watersheds each year. However, actual survival rates for juvenile Chinook salmon released from Elwha Channel Hatchery have been much lower than region-wide rates, likely due to the lack of a properly functioning estuary. WDFW evaluated survival rates to adult return to the Elwha River for brood year 2004 and 2005 releases of subyearling and yearling Chinook salmon from the Elwha Channel Hatchery program. Survival rates for the two brood years averaged 0.065% for subyearlings and 0.015% for yearlings (WDFW 2012). Applying these empirical data for survival rates to the proposed release levels considered in this opinion, the Elwha Channel Hatchery program would be expected to return approximately 1,685 first generation hatchery-origin adult fish (1,655 fish to the Elwha River and 30 fish to Morse Creek). Up to 1,700 adult fish would be required each year just to stock to sustain the hatchery program, assuming 10% holding mortality levels (WDFW 2012).

The recent year average number of naturally spawning Chinook salmon will be used to estimate the number of hatchery-origin fish that would spawn naturally in reaches upstream and downstream of the Elwha dam sites each year. From WDFW (2012), the recent five year (2006-2010) average estimated number of natural spawners was 552 fish. Assuming that 95% of the fish were of hatchery-origin (following fish origin analyses for 2007-2010 from WDFW 2012), the supportive breeding program is expected to contribute approximately 524 spawners to escapements each year. This compares with the potential returning abundance of approximately 88 adult Chinook salmon resulting from natural-origin production alone, assuming continuation of natural-origin smolt production and survival to adult return levels observed for brood year 2004 and 2005 fish (page 12 in WDFW 2012). However, this estmate, only 88 fish, is likely to be overly optimistic considering the expected reduction if fish survivals under existing and at least near term river conditions. Natural-origin adult returns are expected to become very low, perhaps even approaching 0, during and for a period following dam removal as a result of inhospitable and potentially lethal turbidity and sediment levels in the lower river (Ward et al. 2008), and before a properly functioning estuary reforms.

Because the native Elwha Chinook salmon population serves as broodstock, and because a substantial proportion of returning fish will escape to spawn naturally, the program is expected to benefit natural population abundance by preserving the Elwha Chinook salmon population when natural productivity conditions in watershed areas used by Chinook salmon for spawning, rearing, and migration purposes are degraded and inhospitable. During both the preservation and recolonization phases, the supportive breeding program will substantially increase, relative to current and estimated future escapement levels, the abundance (i.e., genetic resources) of Elwha River Chinook salmon.

Lower Elwha Fish Hatchery native steelhead program -

The native steelhead program will be implemented as an integrated recovery program, specifically operated for conservation purposes. All fish produced by the hatchery program will be included with natural-origin Elwha River steelhead as part of the Puget Sound steelhead DPS listed under the ESA. Assuming annual on-station hatchery production of 175,000 2+ smolts, and a survival rate to adult return of 0.75% (from LEKT 2012a), the program would lead to the escapement of 1,313 adult hatchery-origin steelhead to the river each year. Of that total, up to 500 fish will be required as broodstock to sustain the program. Therefore, at least 813 adult steelhead will return to spawn naturally in reaches upstream and downstream of the Elwha dam sites each year, beginning in 2013. This compares with 45 to 246 spawners (LEKT 2012a) without the supportive breeding program and assuming that survivals do not diminish, at least in the short-term, as a result of disturbances caused by dam removal. If survivals decline as expected and without supportive breeding, adult return levels will be much lower than the recent year range, and perhaps 0, during and for a period following dam removal (Ward et al. 2008).

Because the program would propagate the natural-origin winter-run population, and a substantial proportion of total returns would escape to spawn naturally, the program would benefit natural-origin steelhead population abundance by preserving the abundance of Elwha River steelhead that would return to spawn naturally during periods when natural-origin fish productivity conditions in watershed areas used by natural steelhead are degraded and inhospitable as a result of dam removal.

Diversity

In addition to increasing the total number of returning adult salmon, hatcheries can also benefit population and ESU/DPS genetic diversity. Due to the poor status of natural-origin populations in a watershed, genetic resources important to an ESU or DPS may reside in a mitigation program that was developed using the natural-origin population as the donor. In a recent review of the listing status of hatchery-origin steelhead populations, NMFS determined that several hatchery programs in Puget Sound should be included as part of the listed Puget Sound Chinook salmon ESU and Puget Sound steelhead DPS, as they served as genetic reserves and a brood source for rebuilding extant natural-origin Chinook salmon and steelhead populations residing in the watersheds (Ford et al. 2011). Hatchery Chinook salmon populations included as part of the listed ESU are spring Chinook salmon produced by South Fork Nooksack River Hatchery, and fall Chinook salmon produced by the South Fork Stillaguamish Supplementation Program. Hatchery steelhead populaitons included in the DPS were White River Hatchery, Hood Canal Steelhead Supplementation Program, and the native winter population produced through the Lower Elwha Fish Hatchery program.

Over time, propagation practices designed to promote isolation (e.g., broodstock selected to encourage recruitment to the hatchery release sites, and perhaps different timing of adult returns) may lead to the divergence of hatchery-origin fish relative to the natural population. Because the adverse consequences of genetic interactions are likely to increase with the degree of genetic divergence between natural-origin and hatchery-origin fish (Waples 1991; Busack and Currens

1995), isolated hatchery programs operating for mitigation purposes are managed to control the straying of hatchery-origin fish into areas important for natural-origin production and recovery (Mobrand et al. 2005). The performance of an isolated mitigation hatchery program is therefore measured based on its contributions of adult hatchery-origin fish to different fisheries, and on its success in avoiding straying and interbreeding with natural-origin populations in an ESU or DPS (PSTT and WDFW 2004; Mobrand et al 2005). All fish produced through these isolated hatchery programs are intended to be harvested, less the number needed to perpetuate the hatchery program.

Elwha Channel Hatchery Chinook salmon program

The proposed Chinook salmon program will benefit the diversity of the native Elwha Chinook salmon population by preserving and assisting in the recolonization of the unique stock during and for a period following dam removal when natural productivity conditions will be poor. Supportive breeding at Elwha Channel Hatchery, and the creation of a genetic reserve at nearby Morse Creek Hatchery, will preserve the population until prospects for its survival, in the wild, improve. In a past review of the effects of the WDFW hatchery program, the HSRG concluded that it had succeeded in preserving the Elwha Chinook salmon stock over a long period of time, under challenging conditions (HSRG 2002b). Without this supportive breeding effort, the genetically unique Elwha Chinook salmon population would be at high risk of extinction due to current critically low natural-origin fish abundance levels (under 100 adult fish per year) and threats to the remaining population returning to the river posed by dam removal effects. As a "Tier 1" population for ESU recovery (NMFS PRA 2010), the loss of the Elwha Chinook salmon genome, representing one of the two extant populations of the species remaining in the Strait of Juan de Fuca biogeographical region, would be a serious setback and likely prolong the recovery of the Puget Sound Chinook salmon ESU. Increased smolt emigration and adult fish returns that will be afforded by the hatchery program over levels achievable under current natural conditions will help ensure that this unique population is retained to the point where local adaptation and creation of a self-sustaining population, without the need for supportive breeding, will be achieved.

Lower Elwha Fish Hatchery Native steelhead program

The HSRG concluded that the proposed LEKT program would benefit native steelhead population diversity, as the hatchery program may serve as a genetic reserve for the population, assuming appropriate hatchery practices that minimize divergence between the hatchery-origin and natural-origin populations are applied (HSRG 2012). The native steelhead program wikll initially rely on captive brood adults, for hatchery broodstock, that were the progeny of naturally spawning winter-run steelhead collected from the Elwha River. Beginning in 2013, adult fish returning from smolt releases of captive brood progeny will be collected as broodstock randomly over the entire natural-origin steelhead return period. By augmenting the hatchery broodstock collections with adult returns from hatchery smolt releases, starting in 2016, an appropriately sized effective breeding population size (Ne = 500 fish) would be maintained in the program. Natural-origin fish would be incorporated into the broodstock at a high proportion and a factorial mating scheme would be applied at the hatchery during spawning to help preserve the diversity of the native Elwha population retained in the supportive breeding effort. In combination, these practices are expected to minimize divergence between fish produced in the hatchery and the natural population.

Considering these factors, the supportive breeding program will benefit the diversity of the native Elwha River winter-run steelhead population by preserving genetic resources and then accelerating natural recolonization as soon as conditions in the Elwha permit. The program will improve prospects for the continued existence of the population during the preservation phase of restoration. The smolt release portion of the program will assist in recolonization of the Elwha River by the locally adapted native steelhead population as habitat in the watershed recovers.

Without this supportive breeding effort, the genetically unique Elwha River native steelhead population would be subject to unnecessary risk. The population is already at high risk of extinction due to current critically low natural-origin fish abundance levels (43 to 246 adult fish per year) and survival is further threatened from unprecendented conditions in the river and estuary caused by dam removal. The loss of the native steelhead genome, representing an important component of the remaining populations in the Strait of Juan de Fuca major population group, would be a threat to the Puget Sound Steelhead DPS. Increased smolt emigration (175,000 hatchery-origin fish per year) and adult fish returns (estimated at 1,313 fish per year) afforded by the program over levels achievable under natural conditions will help ensure that the unique population is retained to the point where local adaptation of the species, and creation of a self-sustaining exploitable population without the need for supportive breeding will eventually be achieved.

Spatial Structure

The Elwha supportive breeding program is expected to contribute an abundance of fish that spawn naturally - and through density dependent effects, expand and restore the areal extant of the population.

Elwha Channel Hatchery Chinook salmon program

The proposed supportive breeding effort for Elwha Chinook salmon would be operated as an integrated recovery program, with a design to benefit spatial structure of the native Elwha population. One objective is to return adult fish to the hatchery as a result of on-station smolt releases to provide broodstock. The program also has the objective of producing adult returns that would spawn naturally in the Elwha River watershed. As a secondary supportive breeding strategy to on-station smolt releases during the preservation phase, and as a tertiary approach in the recolonization phase, adult hatchery-origin Chinook salmon are expected to be transported and released upstream of the dam sites to spawn naturally. Also, beginning after 2014, as anadromous fish access above the dam sites is restored, adult hatchery fish are expected to return spontaneously and spawn naturally in areas throughout the accessible portions of the Elwha River watershed. As noted previously, the current naturally produced population is extremely small (under 100 fish), further impaired by inhospitable sediment and turbidity levels at least for the near term, and unlikely to adequately seed available habitat for many years. For these reasons, during the preservation and recolonization phases of restoration, the proposed Chinook salmon program will benefit Elwha Chinook salmon population spatial structure above levels achievable through natural production only through production of adult fish that would be transported or escape spontaneously to spawn in the upstream areas unused by the species for 100 years.

Lower Elwha Fish Hatchery Native steelhead program

The supportive breeding program for Elwha River steelhead will be operated as an integrated recovery program, designed to benefit spatial structure of the native Elwha steelhead population. Objectives include creation of a captive broodstock, using naturally spawned juvenile fish as donor, and returns of adult fish to the LEKT hatchery, to preserve and support recolonization of the population. The program also has the objective of producing adult returns that would spawn naturally in the Elwha River watershed. As a secondary supportive breeding strategy during the preservation phase, and a tertiary approach in the recolonization phase, adult hatchery-origin steelhead are expected to be transported and released upstream of the dam sites to spawn naturally. Beginning in 2014, as anadromous fish access above the dam sites is restored, fish released through the program will escape to spawn naturally in areas upstream of the dam sites. The current naturally produced native steelhead population is extremely small (numbering 141 fish on average), and is further impaired by inhospitable sediment and turbidity levels at least for the near term. It is unlikely to adequately seed available habitat for many years. During the preservation and recolonization phases of restoration, the supportive breeding program will benefit population spatial structure through accelerated production of adult fish that would return above levels achievable naturally, and escape to spawn naturally in areas above the dam sites.

Productivity

Generally speaking, supportive breeding does not benefit natural population productivity. Decades of straying by hatchery-origin fish in Puget Sound have not been associated with a commensurate, observed increases in the productivity of any natural-origin Puget Sound Chinook salmon populations (NMFS 2004a). Further, as detailed in section 2.4.1.2, the productivity of natural-origin salmonid populations may be impaired by spawning and genetic introgression from certain hatchery-origin fish species and life history types. Self-sustaining natural production and natural productivity of several summer-run chum salmon populations introduced into streams where the race of the species had become extirpated has been restored over the short term (PNPTT and WDFW 2007), but prospects for retention of the populations over the longer term are unknown.

In the specific case of the Elwha, natural populations of salmon and steelhead are at critically low abundance and returning fish may have difficulty finding mates. Under circumstances like these, supportive breeding is expected to benefit productivity of the natural population (NMFS 2004b).

Elwha Channel Hatchery Chinook salmon program

Under the HGMP, productivity of the Chinook salmon natural population is expected to improve relative to a reliance on natural spawning of natural-origin fish only. During the preservation and recolonization phases of Chinook salmon restoration, returning Chinook salmon, further threatened by dam removal effects, are expected to have difficulty finding mates. Fish from the supportive breeding program that escape to spawn naturally will help to alleviate this problem and thus contribute to natural productivity.

Lower Elwha Fish Hatchery Native steelhead program

As for Chinook salmon, productivity of the native steelhead natural population is expected to improve through implementation of the HGMP relative to a reliance on natural spawning of natural-origin fish only. During the preservation and recolonization phases of restoration, returning natural steelhead, already few in number and further threatened by dam removal effects, are expected to have difficulty finding mates. Fish from the supportive breeding program that escape to spawn naturally will help to alleviate this problem and thus contribute to natural productivity.

All programs

The productivity of listed natural origin salmon and steelhead populations is expected to be improved through ecological engineering services afforded by naturally spawning hatchery-origin adult fish produced by the five proposed programs. Studies have demonstrated that perturbation of spawning gravels by spawning salmonids loosens cemented (compacted) gravel areas used by spawning salmon (Montgomery et al., 1996). The act of spawning also coarsens gravel in spawning reaches, removing fine material that block interstitial gravel flow and reduces the survival of incubating eggs in egg pockets of redds. This latter benefit will be particularly important for improving salmon and steelhead productivity in those portions of the watershed downstream of the dam sites, where sediment impacts on spawning habitat will be extremely adverse. Adult returns and natural spawning by hatchery-origin salmon and steelhead produced by the programs into the lower and upper reaches of the watershed, where spawning by anadromous fish has been either very low due to critically low natural fish abundance levels (lower river), or entirely absent (upper river), will represent a substantial improvement over current conditions, and if natural-origin salmon and steelhead alone were relied on for such ecosystem services.

2.4.2.2.3. *Marine-derived Nutrients*

When anadromous salmonids return to spawn, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. After spawning and dying in the streams, the fish provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Kline et al. 1990; Piorkowski 1995; Larkin and Slaney 1996; Wipfli et al. 1998; Gresh et al. 2000; Murota 2002; and Quamme and Slaney 2003). As a result, the growth and survival of juvenile salmonids may increase (Hager and Noble 1976; Bilton et al. 1982; Holtby 1988; Ward and Slaney 1988; Hartman and Scrivener 1990; Johnston et al. 1990; Quinn and Peterson 1996; Bradford et al. 2000; Bell 2001; Brakensiek 2002). Hatchery programs that increase the number of naturally spawning salmonids will increase nutrient input. NMFS (2005) provides a comprehensive review of the current scientific literature on this subject regarding Chinook salmon harvest management in Puget Sound.

The extent to which natural-origin salmonid production improves from marine-derived nutrients provided by increased anadromous salmonid escapement or the contribution of hatchery-origin salmonid carcasses depends on a complex array of factors that influence the distribution of salmonid carcasses, how long they are retained in the river (before being removed by predators or flushed seaward by floods), how quickly they decompose, and how their nutrient content is retained and utilized within the ecosystem (Glock et al. 1980; Cederholm and Peterson 1985; Cederholm et al. 1989; Michael 1995). Site-specific factors including stream discharge, habitat complexity, basin geology, light, temperature, and stream community structure also affect the overall benefits of the marine-derived nutrients in a given stream (Northcote 1988; Polis et al. 1997; Bisson and Bilby 1998; Murphy 1998; Naiman et al. 2000). The relatively low salmonid spawning escapements in recent years (Gresh et al. 2000) are no doubt exacerbating nutrient limitations and will likely limit the recovery of natural-origin salmonid production in some streams.

The spawning distribution of adults and life history of juvenile salmonids also influences the benefits they derive from carcass nutrients. Juvenile steelhead and coho salmon feed on adult coho salmon carcasses in headwater streams (Bilby et al. 1998). Chinook salmon, pink salmon, and chum salmon, which spawn primarily in mainstem channels or in the lower reaches of tributaries, might provide more direct benefits to their own progeny but their juveniles also tend to rear for a relatively short period in freshwater. Some juvenile salmonids rear in estuarine or delta channels, but the influence of marine-derived nutrients on the productivity of these habitats has not been studied.

Hatchery programs may contribute to marine-derived nutrient input by increasing the number of naturally-spawning salmonids. In addition, co-managers cooperate with local volunteers to distribute carcasses of salmonids that return to hatcheries into many tributaries for nutrient enrichment purposes. Spatial separation between the species, and marine derived nutrient benefits afforded by carcasses, can be attenuated by hatchery carcass distribution programs, which can deposit carcasses into areas not frequented by certain salmon species naturally.

Listed Elwha River Chinook salmon and steelhead willbenefit from the deposition of carcasses resulting from natural escapement and hatchery carcass distribution of adult fish produced by the five hatchery programs considered in this opinion. Decaying carcasses of spawned adult hatchery-origin fish will contribute nutrients that increase productivity in the watershed, providing food resources for naturally produced Chinook salmon and steelhead. Approximately 70 miles of habitat upstream of RM 5 in the Elwha River has been starved of marine derived nutrients for 100 years through preclusion of anadromous fish spawning above the dams. The Elwha River watershed above RM 5 will particularly benefit from implementation of the programs, as anadromous salmonids, which historically provided carcasses before the dams were constructed, will return as a source of marine-derived nutrients through upstream releases of adult hatchery-origin fish and through spontaneous escapement after anadromous fish access is restored in 2014. With natural spawning by hatchery-origin fish, and any hatchery carcass seeding efforts, a substantial amount of decaying fish, and marine derived nutrients will be deposited over the preservation and recolonization phases of restoration (Table 20). The annual number of salmon and steelhead carcasses will increase in the upper watershed, as would marine-derived nutrient benefits, as the progeny of naturally spawning hatchery- and natural-origin fish increase in adult return abundance over time, and as the species re-establishes in the newly accessible habitat.

Table 20. Estimated biomass of marine-derived nutrients (MDN)[1] that would be transported upstream and deposited by adult first generation hatchery-origin salmon and steelhead returning to the Elwha River for natural spawning and from carcass distribution from the hatcheries during the preservation and recolonization phases of restoration.

Species	Juvenile Fish Release Level (Goals)	% Survival to Adult Return (Escapement) 3/	Total Adult Escapement to the Elwha River	Average Individual Adult Fish Weight (lbs)	Potential MDN Biomass (lbs)
Chinook salmon 2/	2.5 million	0.065%	~1,700	18.0	30,600
Steelhead	175,000	0.75%	1,313	8.0	10,500
Coho salmon	425,000	2.5%	10,635	7.0	74,375
Fall chum salmon	450,000	0.44%	2,000	10.0	20,000
Pink salmon	350,000	0.5%	1,750	3.5	6,125
TOTAL	-	-	-	-	141,600

1/ Estimated MDN deposition assumes that no fishery removals of the hatchery-origin fish would occur during the initial phases of restoration.

2/ Production reflects subyearlings only, which would produce the majority of estimated adult returns to the river.

3/ Juvenile fish survival rate to adult return to the Elwha River estimates are goal levels from the HGMPs for steelhead, coho salmon (average of 1% to 5% range), fall chum salmon, and pink salmon. Survival rate for Chinook salmon assumes average rate observed for actual hatchery-origin returns for the 2004 and 2005 brood years (WDFW 2012).

2.4.2.3 Critical Habitat

Critical habitat for the listed species, where designated, is described in section 2.4.4. The action area included the portions of the Elwha River watershed that have been designated as essential for spawning, rearing, juvenile migration, and adult migration of listed Puget Sound Chinook salmon and eulachon. Although critical habitat has not yet been designated for Puget Sound steelhead, the critical habitat area, features and PCEs defined for Chinook salmon are assumed to adequately reflect parameters important for steelhead in the Elwha River. In the action area there are numerous factors affecting PCEs, including, but not limited to: altered channel morphology and floodplain; sediment deposition starvation (pre-dam removal), excessive sediment (post dam-removal) and disrupted sediment routing processes; reduced spawning and rearing habitat; degraded water quality and riparian habitat; disrupted large woody debris occurrence; and blocked upstream passage for migration. Operation of the hatchery programs is not expected to substantially impact PCEs within the action area. Hatchery facilities are either located high in the floodplain, or are protected by dikes authorized previously through other ESA consultations (NMFS 2006a), and have not led to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment, or the loss of habitat diversity. The hatchery facilities are designed and will be used such that they would not reduce access to spawning and rearing habitat, or increase water temperatures.

In evaluating essential habitat features that could potentially be affected in the Elwha River Basin that were not previously reviewed and authorized through separate NMFS consultations (i.e., surface water withdrawal structures and levels - NMFS 2006a; 2010b; 2012a, as included in the environmental baseline), NMFS found that impacts would be limited to listed fish spawning and rearing sites in the Elwha River, and water quantity and quality associated with hatchery facility groundwater withdrawals and effluent discharge. Potential impacts on critical habitat evaluated for Puget Sound Chinook salmon and eulachon were limited to competition for freshwater spawning sites from hatchery-origin adults and their progeny, and competition for freshwater rearing sites from juvenile fish released from the programs and the progeny of naturally spawning hatchery-origin adults.

In reviewing the effects of the proposed action on critical habitat water quantity, NMFS determined that the impacts from removing groundwater through wells at the hatcheries will not have a measureable effect on the volume of surface water available to listed fish in the Elwha River. Groundwater withdrawals are not expected to reduce freshwater spawning and rearing habitat areas or the quality of those areas to levels that would have any discernible effects on listed juvenile or adult fish that may be present in the area adjacent to the Elwha Channel Hatchery and Lower Elwha Fish Hatchery facilities.

NMFS determined that the impacts on critical habitat water quality resulting from the hatchery effluent discharge willnot have a substantial effect on the quality of water available in Elwha River basin waters downstream of the hatchery locations. All facilities proposed for use through the programs have been issued NPDES effluent discharge permits by the appropriate state or federal water quality regulatory authorities (WDOE or USEPA). Water quality standards and effluent discharge monitoring requirements attached with the permits minimize the risk that the hatchery programs would substantially affect the quality of water in the Elwha River downstream of the hatcheries to a condition where downstream aquatic life, including listed fish, would be discernibly affected.

The five hatchery programs would potentially impact critical habitat for Puget Sound Chinook salmon and eulachon through the production of juvenile and adult fish that may compete with listed natural-origin fish for spawning and rearing sites in the Elwha River. With restoration of anadromous fish access to 70 additional miles of potential spawning and rearing habitat after the dams are fully removed in 2013, NMFS expects that the availability and quality of critical habitat for listed Puget Sound Chinook salmon and eulachon will be substantially increased. The expected number of hatchery-origin adult fish produced over the restoration periods proposed in the HGMPs that willspontaneously escape, or be transported upstream and released, to spawn naturally will not lead to measureable effects on the quality of critical spawning habitat for these listed species. Because all juvenile hatchery-origin fish would be released directly into the Elwha River from locations low in the watershed, and considering the substantial increase in the quantity of high quality habitat accessible to anadromous fish beginning in 2013, NMFS expects that there will be no reduction in availability or quality of critical rearing habitat for the listed species resulting from implementation of the hatchery programs as proposed.

2.5. Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act. For the purpose of this analysis, the action area is that part of the Elwha River Basin described in the section 1.4, above.

Volume II of the Shared Salmon Strategy for Puget Sound (SSPS 2007) includes a section for Strait of Juan de Fuca Chinook salmon populations that describes in detail the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to listed Chinook salmon in the Elwha River Basin. Future tribal, state and local government actions will likely to be in the form of legislation, administrative rules, or policy initiatives, and land use and other types of permits. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. These realities, added to the geographic scope of the action area, which encompasses numerous government entities exercising various authorities and the many private landholdings, make any analysis of cumulative effects difficult and speculative.

Non-Federal actions are likely to continue affecting listed species. The cumulative effects of non-Federal actions in the action area are difficult to analyze considering the geographic landscape of this opinion, the political variation in the action area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation, with the likelihood for future effects depending on the activity affecting the species, and the non-Federal entity regulating the activity. However, we expect the activities identified in the baseline to continue at similar magnitudes and intensities as in the recent past. On-going salmon restoration and recovery actions implemented through the Shared Strategy Plan (Ruckleshaus et al. 2005) would likely continue to help lessen the effects of non-Federal land and water use activities on the status of listed fish species. The temporal pace of such decreases would be similar to the pace observed in recent years. With these improvements, however, based on the trends discussed above, there is also the potential for adverse cumulative effects associated with some non-Federal actions to increase (Judge 2011). State, tribal, and local governments have developed resource use plans and initiatives to benefit listed fish and off-set any growing adverse effects that are proposed to be applied and sustained in a comprehensive way (e.g., SSPS 2005). But the actions must actually be funded and in the process of implementation (most are not) before NMFS can consider them “reasonably foreseeable” in its analysis of cumulative effects, and it is speculative for NMFS to do so given these uncertainties.

2.6. Integration and Synthesis

This section is the final step of NMFS’ assessment of the effects on listed fish species and critical habitat as a result of implementing the proposed actions. In this section, we add the effects of the actions (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to formulate the agency’s biological opinion as to whether the proposed actions are likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2).

NMFS has evaluated the effects of the proposed hatchery plans throughout the four phases of Elwha fish recovery – preservation, recolonization, local adaptation and self-sustaining -- to the best of its abilities. While these latter two phases have been generally evaluated for effects of the entire proposed action, due to uncertainty regarding future conditions and effects, consultation will need to be reinitiated for the local adaptation and full restoration phases to ensure full compliance with the ESA.

2.6.1. Puget Sound Chinook salmon

The effects of the supportive breeding activities for Elwha River salmon and steelhead populations described in section 2.4 are not expected to appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the Puget Sound Chinook salmon ESU. NMFS evaluated the proposed programs for both benefits and risks, and considering available scientific information and the facts specific to the Elwha, has concluded that the proposed supportive breeding programs are likely to benefit the biological status of ESA listed Chinook salmon and steelhead.

After taking into account the current crtically depressed viability status of the species, the baseline, including threats asscociated with the effects of dam removal, and pertinent cumulative effects, NMFS concludes that the Puget Sound Chinook salmon ESU and the Puget Sound steelhead DPS will be at greater risk if supportive breeding, as described in the HGMPs, is not implemented.

Risks posed by the hatchery programs include facility operation (groundwater withdrawals and effluent discharge), genetic effects (within population diversity reduction, among population diversity reduction, and hatchery-induced selection effects), ecological effects (competition and predation), and monitoring and evaluation effects (methodology impacts). Other potential risks from the proposed hatchery programs (e.g., surface water withdrawal, broodstock collection, and harvest effects) were previously evaluated and authorized through separate NMFS ESA consultation processes (NMFS 2006a; 2010b; 2012a), and are included in the environmental baseline. Benefits from the supportive breeding programs that outweigh these risks are preservation and growth in available genetic resources at the population level and a corresponding reduction in short-term extinction risk.

Facility operation effects, including groundwater withdrawal and hatchery effluent discharge impacts were evaluated and determined unsubstantial. Groundwater withdrawal levels to support the hatchery operations would be very small relative to the total volume of water available for fish in the Elwha River. Effluent discharge would likewise be unsubstantial and regulated under federal NPDES permits to ensure that downstream aquatic life, including listed Chinook salmon, steelhead, and eulachon, would be protected from any hatchery-related water quality impacts.

Genetic effects including within and among population diversity reduction and hatchery-induced selection risks were evaluated and the conclusion is that the overall effect of the programs would be positive. It is highly likely that supportive breeding provided through past hatchery propagation at the hatchery has preserved the extant population and what remains of the genetic characteristics of the species. The extant within population diversity of the Elwha Chinook salmon population is largely an artifact of artificial selection that has likely occurred over the long-term operation of the hatchery program. Existing genetic diversity has been substantially supported by the hatchery program, and would continue to be supported during the periods when the condition and productivity of habitat will be severely degraded by dam removal. The safety net portion of the program established at Morse Creek Hatchery would assist in genetic diversity preservation. Risk reduction measures, consistent with NMFS (2012b), will limit unnecessary risk to within population diversity.

There is no reason to believe that the supportive breeding program is a threat to other Chinook salmon populations in the vicinity. Implementation of measures in the HGMP will reduce the risk of outbreeding depression and straying resulting from adult hatchery-origin fish returning to the Elwha River and Morse Creek release sites. For these reasons, the risk of outbreeding depression associated with implementation of the proposed program to the naturally spawning Chinook salmon population in the Elwha River action area was determined to be unsubstantial. Hatchery management measures in the HGMP are consistent with NMFS (2012b) and are expected to sufficiently reduce the risk of outbreeding depression.

In view of the management history of the Chinook salmon population (i.e., hatchery-origin fish have likely composed the majority of Chinook salmon spawning naturally in the river for decades; mainstem river broodstock collection practices have led to the collection of fish representative of the total returning run), the Elwha Channel Hatchery supportive breeding program is not likely to lead to substantial, additional hatchery-induced selection risks to the Elwha Chinook salmon population. As the program operates to conserve genetic resources, protective measures will be implemented to reduce the risk of unintentional hatchery-induced selection, and biased sampling effects on Elwha Chinook salmon population diversity and fitness. Risk reduction measures will be implemented that minimize hatchery induced selection risks, as per NMFS (2012b).

Competition for food, space, and resources between fish from the selective breeding program and natural-origin fish will be a rare occurrence or absent altogether. Because of severely limiting habitat conditions, there are expected to be few natural-origin Chinook salmon in the watershed and thus any interactions, let alone competitive interactions, are expected to be inconsequential or a rare event. However, as an additional safeguard against detrimental interactions all hatchery-origin fish would be released only as seaward migrating smolts and only directly from the hatcheries, which are located in the lowest portions of the watershed. On-station hatchery fish releases would also be timed to avoid periods when juvenile Chinook salmon would be emerging and emigrating. Only adult hatchery-origin fish would be released off-station, into upstream areas to spawn naturally. The progeny of the naturally spawning hatchery-origin fish would pose unsubstantial competition risks to any co-occurring Chinook salmon produced by natural-origin spawners. The progeny of naturally spawning hatchery fish would have no competitive advantages in size and egression timing, and resources would be expected to be partitioned between species consistent with what occurs naturally. Additional measures, consistent with those described in NMFS (2012b), will be implemented to further minimize the potential for competitive interactions that put natural-origin fish at a disadvantage.

Available information and analysis reveals that there is little or no risk of predation on fish from the natural population. There will be little interaction or co-occurrence between hatchery-origin fish and rearing and migrating listed Chinook salmon. The hatchery-origin fish would be released only as seaward migrating smolts and only directly from the hatcheries, which are located in the lowest portions of the watershed, limiting spatial and temporal overlap with any co-occurring juvenile Chinook salmon. On-station hatchery fish releases would also be timed to avoid periods when juvenile Chinook salmon of a size vulnerable to predation would be emerging and emigrating. Only adult hatchery-origin fish would be released off-station, into upstream areas to spawn naturally. The natural-origin progeny of the naturally spawning hatchery-origin fish would pose unsubstantial predation risks to any co-occurring listed Chinook salmon, as the young-of-the-year fish of both groups would be of similar size during their shared rearing and emigration periods. Adequate risk reduction measures, consistent with those identified in NMFS (2012b), will be implemented to further minimize risks.

Harvest impacts on listed fish associated with the production of hatchery-origin Chinook salmon through the Elwha Channel Hatchery program have been previously evaluated and authorized by NMFS (NMFS 2011b) and are included in the environmental baseline. Under the proposed action, WDFW would apply an adipose fin clip mark to all yearling fish beginning with release year 2012, and to a small proportion of the sub-yearling releases beginning in 2013. Application of this mark is expected to provide useful information for Chinook salmon recovery at the expense of approximately 48 fish, or 2.8% of the total escaping population.

Monitoring and evaluation activities will impact listed Chinook salmon. Sampling (scale, tissue, mark/tag and/or otolith) of adults returning to the hatcheries (live and dead fish) and escaping to spawn naturally (usually carcasses) to assess fish species status, origin, and fish health status would lead to takes of listed Chinook salmon. Up to 1,700 Chinook salmon, primarily listed hatchery-origin fish, will be collected for hatchery broodstock purposes. Hatchery fish that are distinguishable from natural-origin fish and that are included in an ESU or DPS listed as threatened, are not subject to take prohibitions under section 9 (70 FR 37160, June 28, 2005). A subset of the carcasses from naturally spawning Chinook salmon would be subject to sampling and take each year. Marking and/or tagging of hatchery Chinook salmon will occur to allow for assessment of hatchery program performance. Up to 2.9 million hatchery Chinook salmon (up to 2.5 million subyearlings and 400,000 yearlings) will be marked each year. Sampling of Chinook salmon reared in the hatchery and prior to their release for fish health monitoring purposes would lead to the handling, injury and mortality of a subset of the total number of fish produced each year. These monitoring and evaluation actions, in total, are designed to help manage and protect listed Chinook salmon and will not pose a substantial risk to the natural Chinook salmon population. Risks will be at least partially ameliorated by application of risk minimization measures described in the HGMPs.

The supportive breeding program is expected to confer benefits to the total abundance of the Elwha Chinook salmon population. Contributions of adult hatchery-origin Chinook salmon will increase total Chinook salmon adult returns to the Elwha River. Total abundance for the species will be substantially greater than without the supportive breeding program when sediment and turbidity levels in the lower river will disrupt natural-origin fish survival and productivity. With contributions from naturally spawning hatchery fish, increases in total Chinook salmon abundance resulting from the return of first generation hatchery adult fish will contribute substantially to the achievement of naturally spawning fish abundance triggers established for the preservation and recolonization phases (Table 3).

Viability parameters for the Elwha River Chinook salmon population will benefit from implementation of the supportive breeding program. The program would propagate the natural-origin stock, and a substantial proportion of total returns would escape to spawn naturally. Natural population abundance is expected to increase, relative to expectations without the selective breeding program.

The Chinook salmon supportive breeding program will benefit the diversity of the native Elwha Chinook salmon population by preserving and assisting in the recolonization of the unique stock during and for a period following dam removal when natural productivity conditions will be poor. Prevention of the loss of the Elwha Chinook salmon genome, representing one of the two extant populations of the species remaining in the Strait of Juan de Fuca biogeographical region, will be important for recovery of the Puget Sound Chinook salmon ESU. Supportive breeding of the population at Elwha Channel Hatchery, and creation of a genetic reserve for the stock at Morse Creek Hatchery, will prevent the possible extirpation of the population, allowing for its persistence as the source population for all four phases of Chinook salmon restoration in the Elwha River.

The proposed Chinook salmon program will benefit Elwha Chinook salmon population spatial structure through production of adult fish that would escape to spawn in the areas unused by the species for 100 years. Hatchery-origin fish escaping spontaneously, hatchery-origin fish trucked upstream and released, and the progeny of these naturally spawning hatchery fish will extend substantially population spatial structure relative to levels and capabilities observed for natural-origin Chinook salmon at the present time and as expected in subsequent years.

Improvements in Chinook salmon productivity in previously vacant habitat upstream of the dam sites may be accelerated by adult fish production, escapement, and spawning by hatchery-origin Chinook salmon over the short term relative to reliance on natural-origin fish production only, which is currently at critically depressed levels that are further threatened by dam removal effects. Because the natural population is at very low abudance, the supportive breeding program will enhance the probability of fish finding mates and thus natural productivity is expected to improve, relative to conditions without the supportive breeding program.

The proposed hatchery programs will contribute substantially to marine-derived nutrient input in the Elwha River watershed at levels beneficial to Chinook salmon by increasing the number of naturally-spawning salmonid carcasses, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase productivity in watershed areas, enhancing food resources for naturally produced Chinook salmon. Approximately 70 miles of habitat upstream of RM 5 in the Elwha River has been starved of marine derived nutrients for 100 years through preclusion of anadromous fish spawning above the dams. The Elwha River watershed above RM 5 will particularly benefit from implementation of the program, as anadromous salmonids which historically provided carcasses before the dams were constructed would return as a source of marine derived nutrients through upstream releases of adult hatchery-origin fish and through spontaneous escapement after anadromous fish access is restored at the Glines Canyon Dam site in 2013.

Long-Term Effects on Recovery

NMFS' evaluation of the effects of the proposed supportive breeding programs on listed Chinook salmon addresses, to the best of its abilities, effects expected over the longer term, and spanning all four phases of fish restoration. Expected risk and benefit effect levels for Elwha River Chinook salmon for the intitial two phases of restoration – the preservation and recolonization phases – have less uncertainty than effects expected for the latter local adaptation and self-sustaining phases. Reasonable expectations can be appied regarding the current and near-term future viability status of the population, and the condition and productivity status of watershed habitat affected by dam removal activities, for these initial phases, as can the performance and effects of the supportive breeding program.

However, there is greater uncertainty regarding the latter phases of restoration. There has never been a project of the magnitude of the Elwha River dam removal effort to serve as a template to estimate future effects with any certainty. The expected dynamic and largely unpredictable nature of natural and hatchery Chinook salmon survival and productivity, watershed habitat condition and productivity, and scientific uncertainty regarding the pace of watershed recovery from dam removal effects, add to this uncertainty. Nevertheless, it is feasible to reach broad effects conclusions regarding supportive breeding program effects on rcecovery over the longer term considering the specific actions proposed to minimize risks, and impart benefits, and how these risks and benefits would affect listed Chinook salmon in the latter phases of restoration.

A primary supportive breeding effect carried forward over the longer term and across the latter phases of restoration is preservation of the Elwha River Chinook salmon population (WDFW 2012). As described above, NMFS concludes that the supportive breeding program for the species will preserve an already critically small population during a period when watershed conditions are inhospitable to natural Chinook salmon survival and productivity. Lacking the supportive breeding program, the population will be at risk of extirpation. Implementation of the program will sustain the genetically unique, native Chinook salmon that has evolved within the watershed so that it is available to locally adapte and become self-sustaining over the longer term. Without the supportive breeding program for the species, it is likely that there would be no native population remaining to benefit restoration in the latter phases. Benefits afforded by the program to total population abundance and natural Chinook salmon viability will be monitored throughout the four restoration phases to ensure the supportive breeding effort is assisting restoration, as evaluated in the preceding sections.

Conclusions regarding the demographic, genetic, and ecological risks to listed Chinook salmon described in this section can reasonably be assumed to apply over the longer term as worse case outcomes for the following reasons. Risks posed by the supportive breeding programs are assessed based on current juvenile and adult hatchery fish production levels. In the preceding sections, NMFS concludes that risks associated with the programs as described in the HGMPs will not substantially affect listed Chinook salmon. The program is implemented applying measures that will reduce the risk of adverse effects on listed Chinook salmon. Monitoring and evaluation actions will be implemented to identify program performance in meeting Chinook salmon resatoration objectives. Over the longer term, as the Chinook salmon population meets viability triggers for each restoration phase (Table 3), as identified through monitoring and evaluation of Chinook salmon status, the program will be adjusted accordingly, and risks will be reduced relative to those assessed under the proposed HGMP. For example, when Chinook salmon population viability triggers for the restoration phase are met, and the status of the natural Chinook salmon population improves, the number of supportive breeding program-origin adult fish spawning naturally will be reduced. This reduction will occur through decreases in the number of juvenile fish released, and/or removal of adult hatchery fish from the river. These responsive program adjustment acitons will result in reductions in the genetic and ecological effects determined as unsubstantial at current hatchery fish production levels. As the status of natural Chinook salmon improves into the self-sustaining phase of restoration, consistent with criteria in Table 3, no hatchery fish will be needed for natural spawning to sustain the Elwha Chinook salmon population at a viable level, and the program will be terminated. Any risks associated with supportive breeding identified for the proposed actions in this opinion will therefore be entirely removed. The need to terminate the program would be consistent with NMFS population viability and delisting criteria, as populations relaint on artificial propagation are not viable, and can not be considered recovered until supportive breeding actions are phased.

In summary, it is NMFS' assessment that the Elwha Chinook salmon population will benefit over the longer term, and across all four restoration phases, as a result of preservation and recolonization assistance afforded by the supportive breeding program. The population will be better off with the program, relative to no program at all, because the population would be placed at risk of extirpation lacking supportive breeding when watershed conditions are inhospitable, making the population unavailable for restoration of the species over the longer term. Risks assessed for the program and determined to be unsubstantial in effect on listed Chinook salmon in this opinion represent worst case outcomes for the latter restoration phases. Risk levels will be further reduced as adult escapement and juvenile release numbers are adjusted downward.

Although the latter two phases have been generally evaluated for effects of the entire proposed action, due to uncertainty regarding future conditions and effects, consultation will need to be reinitiated for the local adaptation and full restoration phases to ensure full compliance with the ESA.

NMFS has determined that the potential negative impacts on natural-origin Puget Sound Chinook salmon would be adequately minimized through the proposed actions, that these impacts would not rise to the level of a serious adverse effect on the ESU, and that these effects would be sufficiently monitored to determine if further action is needed. Based on the effects conclusions presented above, the risk to survival and recovery of this species will be reduced through implementation of the supportive breeding program. The analysis above has considered recovery planning documents and the potential effects of the proposed propagation programs on the listed Chinook salmon population, combined with other ongoing activities within the action area, and determined that the proposed hatchery programs would not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the Puget Sound Chinook salmon ESU or the Elwha population component of the ESU.

2.6.2. Puget Sound Steelhead

The effects of the supportive breeding activities for Elwha River salmon and steelhead populations described in section 2.4 are not expected to appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the Puget Sound steelhead ESU. NMFS evaluates artificial propagation programs for both benefits and risks, and considering available scientific information and the facts specific to the Elwha River, has concluded that the proposed supportive breeding programs are likely to benefit the biological status of ESA listed Chinook salmon and steelhead.

After taking into account the current crtically depressed viability status of the species, the baseline, including threats asscociated with the effects of dam removal, and pertinent cumulative effects, NMFS concludes that the Puget Sound Chinook salmon ESU and the Puget Sound steelhead DPS will be at greater risk if supportive breeding, as described in the HGMPs, is not implemented. Risks posed by the hatchery programs include through facility operation (groundwater withdrawals and effluent discharge), genetic effects (within population diversity reduction, among population diversity reduction, and hatchery-induced selection effects), ecological effects (competition and predation), harvest effects, and monitoring and evaluation effects (methodology impacts). Other potential risks from the proposed hatchery programs (e.g., surface water withdrawal, broodstock collection, and harvest effects) were previously evaluated and authorized through separate NMFS ESA consultation processes (NMFS 2006; 2010b; 2012a), and are included in the environmental baseline. Benefits from the supportive breeding programs that outweigh these risks are preservation and growth in available genetic resources at the population level and a corresponding reduction in short-term extinction risk.

Facility operation effects, including groundwater withdrawal and hatchery effluent discharge impacts were evaluated and determined unsubstantial. Groundwater withdrawal levels to support the hatchery operations would be very small relative to the total volume of water available for fish in the Elwha River. Effluent discharge would likewise be unsubstantial and regulated under federal NPDES permits to ensure that downstream aquatic life, including listed Chinook salmon, steelhead, and eulachon, would be protected from any hatchery-related water quality impacts.

Genetic effects including within and among population diversity reduction and hatchery-induced selection risks were evaluated and the conclusion is that the overall effect of the programs will be positive. The within population diversity of the remaining native Elwha River steelhead population may be adversely affected by the proposed captive breeding and juvenile steelhead release program, because only a subset of the current total population may be included as hatchery broodstock. However, the supportive breeding for the species, including captive broodstock production, is needed to preserve remaining diversity of the native winter-run population. Because of inhospitable habitat conditions created by the dams for natural-origin steelhead production over the long term, the native population has been driven to critically low abundance levels, with substantial reductions in the diversity of the population relative to its historical baseline. The remaining abundance and diversity of the population are further threatened by dam deconstruction activities and effects on remaining lower river habitat. Existing genetic diversity expressed by the total population will be substantially supported by the proposed hatchery program for at least two brood years, and pending the rate of recovery of critical habitat, all brood years for the species. Risk reduction measures, consistent with NMFS (2012b), will limit unnecessary risk to within population diversity.

There is no reason to believe that the supportive breeding program is a threat to other steelhead populations in the vicinity. Implementation of measures in the HGMP will reduce the risk of outbreeding depression and straying resulting from adult hatchery-origin fish returning to the Elwha River. The proposed native winter-run steelhead hatchery program propagates the native Elwha River stock, and outbreeding depression effects on the remnant wild population in the Elwha River would therefore not be a risk factor. Until recently, production of winter-run steelhead in the Elwha River basin included releases of out-of-basin origin Chambers Creek hatchery-lineage winter-run steelhead. Considering the need to reduce the risk of among population diversity loss to the native winter-run steelhead population, the LEKT terminated the Chambers steelhead release program in 2012. Genetic analyses conducted by NMFS indicate that genetic introgression effects on the native Elwha River steelhead population resulting from the now terminated LEKT program have been unsubstantial. As a further measure to reduce genetic diversity risks, the LEKT has proposed directed fisheries in 2012-2013 and 2013-2014 to remove adipose-finned clipped steelhead escaping into lower Elwha River spawning areas during the Chambers Creek steelhead return period (LEKT 2012a). The co-managers will also maintain hatchery weirs and traps open, and operate the mainstem Elwha River weir at RM 3.7 if feasible, to collect and cull any adipose fin-clipped (Chambers Creek lineage) steelhead encountered (LEKT 2012a). Adjacent watersheds harboring natural-origin distinct independent populations of steelhead where Elwha River hatchery-origin steelhead might stray and spawn include Morse Creek, Dungeness River, and miscellaneous tributaries to Sequim and Discovery bays. The first adult returns of native stock hatchery-origin steelhead will return in 2013, so there are as yet no data available regarding stray rates for adult fish produced through the program that would potentially pose outbreeding depression risks to these neighboring steelhead populations. Any outbreeding depression risks to other populations that would be posed by the proposed program are unknown and would be speculative. However, genetic analyses have showed that other natural-origin Puget Sound steelhead populations have contributed substantially to the current genetic character of Elwha River native steelhead. Natural straying and spawning by non-native, but natural-origin stocks from adjacent Puget Sound watersheds have contributed to the extant diversity of the Elwha River population. A distinct genetic signature for Elwha River native winter-run steelhead persists, however. For these reasons, the risk of outbreeding depression associated with implementation of the proposed program to the naturally spawning Chinook salmon population in the Elwha River action area was determined to be unsubstantial. Hatchery management measures in the HGMP are consistent with NMFS (2012b) and are expected to sufficiently reduce the risk of outbreeding depression. Risk reduction measures are included for implementation in the proposed native steelhead hatchery plan that would minimize within population diversity reduction risks.

The proposed program would likely result in some hatchery-induced selection risks to the steelhead population remaining in the Elwha River. Some degree of effects associated with this hazard would likely be unavoidable for the program, given that not all adult fish and families of aggregate hatchery- and wild-origin steelhead returning to the Elwha River each year were used to found the captive broodstock propagated in the program, nor would the entire population be collected and retained as broodstock when returning as adults. Hatchery-induced selection effects would also likely result, given exposure of the population to a relatively high degree of hatchery intervention associated with the proposed supportive breeding actions (i.e., captive broodstock rearing; 2+ smolt production). The 2011 steelhead brood was last collected to create captive broodstock, and no further production of fish under this highest level of hatchery intervention would occur. Rearing of juvenile steelhead for two years in the hatchery prior to their on-station release would confer further selection risks as the fish are propagated for an extended period, and for a substantial proportion of their total life spans, in an artificial rather than a natural setting. Hatchery-origin steelhead adult transported and released to spawn naturally as the secondary supportive breeding action would have a low risk of further hatchery-induced selection risks because the spawning fish and their progeny would be exposed to selective pressures entirely in the natural, rather than hatchery, environment. Considering the current critically low abundance status of the native steelhead population in total, and threats to its persistence over the short term as a consequence of dam removal, hatchery-induced selection risks associated with the proposed program are out-weighed by demographic risks to the population. The proposed program would preserve what remains of the native steelhead population, and functioning over just the initial two phases of restoration, would be unlikely to result in substantial, additional hatchery-induced selection risk to the steelhead population over the duration of proposed action. Genetic risk management measures are proposed in the HGMP that would reduce the risk of intentional or unintentional hatchery-induced selection, and biased sampling effects on Elwha River native steelhead population diversity and fitness.

Competition for food, space and resources with fish produced through the five proposed hatchery programs is not expected to adversely impact listed steelhead because there would be little interaction or co-occurrence between hatchery-origin fish and rearing and migrating steelhead. Because of severely limiting habitat conditions and the currently very low abundance and productivity status for steelhead in the basin, there are expected to be few natural-origin steelhead in the watershed during the preservation and recolonization phases that would be affected by competition with hatchery-origin fish. However, to limit the duration of any interactions, and spatial and temporal overlap with naturally produced steelhead, all hatchery-origin fish would be released as juveniles only as seaward migrating smolts and only directly from the hatcheries, which are located in the lowest portions of the watershed. On-station hatchery fish releases would also be timed to avoid periods when juvenile steelhead would be emerging and emigrating. Only adult hatchery-origin fish would be released off-station, into areas upstream of the dam sites to spawn naturally. The natural-origin progeny of the naturally spawning hatchery-origin fish will not have any competitive advantages over co-occurring natural-origin steelhead, and would pose unsubstantial competition risks in those upstream areas. Adequate hatchery risk reduction measures are proposed for implementation in the five proposed hatchery plans to minimize competition risks.

Available information and analysis reveals that predation by fish produced through the proposed hatchery programs would not adversely impact listed steelhead. There would be little interaction or co-occurrence between hatchery-origin fish and rearing and migrating listed steelhead. The hatchery-origin fish would be released as juveniles only as seaward migrating smolts and only directly from the hatcheries located in the lowest portions of the watershed, limiting the duration of overlap with any co-occurring listed juvenile fish. On-station hatchery fish release would also be timed to avoid periods when juvenile steelhead of a size vulnerable to predation would be emerging and emigrating. Only adult hatchery-origin fish would be released off-station, into upstream areas to spawn naturally. The natural-origin progeny of the naturally spawning hatchery-origin fish would pose unsubstantial predation risks to any co-occurring listed salmon and steelhead, as the fish would be of similar size during their shared rearing and emigration periods.   Adequate risk reduction measures are proposed for implementation in the hatchery plans to minimize predation risks to listed steelhead.

Harvest impacts on listed fish associated with the harvest of the last returning brood years of non-native Chambers Creek steelhead, implemented as a risk reduction measure under the LEKT steelhead HGMP (LEKT 2012a), have been previously evaluated and authorized by NMFS (NMFS 2011b) and are included in the environmental baseline.

Monitoring and evaluation activities to determine effects on listed fish and hatchery program performance will impact listed steelhead.   Methods used to conduct spawning ground surveys proposed to assess the abundance (numbers of adults or redds), distribution, and origin (hatchery or natural) of salmon and steelhead escaping to spawn naturally would potentially harm listed juvenile and adult steelhead present in river reaches surveyed. The abundance and productivity levels of naturally spawning steelhead would potentially be adversely affected by the proposed surveys, but the magnitude of any effects are unknown and unquantifiable. Sampling (scale, tissue, mark/tag and/or otolith) of adults returning to the hatcheries and escaping to spawn naturally (usually carcasses) to assess fish species status and origin would lead to takes of listed steelhead. Assuming achievement of goal broodstock collection and/or adult fish return levels to the hatcheries, up to 500 steelhead taken into the hatchery would be affected each year by sampling. Because they are all marked with an identifying tag, otolith band or fin clip as juvneiles prior to release, Elwha River hatchery steelhead are distinguishable from natural-origin fish are included in the Puget Sound steelhead DPS, are not subject to take prohibitions under section 9 (70 FR 37160, June 28, 2005). A subset of the total annual number carcasses from naturally spawning steelhead would be subject to sampling and take each year. The number that would be affected is unknown and unquantifiable at this time. Marking and tagging of all juvenile steelhead released through the hatchery program to allow for assessment of program performance and effects would lead to takes of up to 175,000 steelhead each year. Sampling of steelhead reared in the hatchery and prior to their release for fish health monitoring purposes would lead to the handling, injury and mortality of a subset of the total number of fish produced each year. These monitoring and evaluation actions, in total, are designed to help manage and protect listed steelhead and will not pose a substantial risk to the natural steelhead population.   Risks will be at least partially ameliorated by application of risk minimization measures described in the HGMPs.

The steelhead supportive breeding program is expected to confer benefits to the total abudance of listed Elwha River steelhead. Contributions of adult hatchery-origin steelhead that are part of the ESA-listed DPS in the Elwha River resulting from implementation of the hatchery program would increase the total abundance – hatchery-origin plus natural-origin - of the listed population. Total steelhead abundance augmented by the hatchery program will be substantially greater than abundance produced by natural production alone during the initial phases of restoration, when sediment and turbidity levels in the lower river will disrupt natural-origin fish survival and productivity. With contributions of the progeny of naturally spawning hatchery fish, total steelhead abundance benefits from the return of first generation hatchery adult fish would contribute substantially to the achievement of naturally spawning fish abundance triggers established for the preservation and recolonization phases (Table 4).

Elwha River steelhead population viability parameters would also benefit from implementation of the proposed steelhead program. The supportive breeding program would propagate the natural-origin stock, and a substantial proportion of total adult returns would escape to spawn naturally. As a result of the supportive breeding program, natural-origin steelhead population abundance would benefit by preserving and helping to seed the watershed with naturally spawning fish in future years.

The supportive breeding program for steelhead will benefit the diversity of the native Elwha River steelhead population by preserving and assisting in the recolonization of the unique stock during and for a period following dam removal when natural productivity conditions will be poor. Preservation of the Elwha River steelhead population is important for retaining existing genetic diversity needed for recovery of the Puget Sound steelhead DPS. Supportive breeding of the population at Lower Elwha Fish Hatchery will prevent the possible extirpation of the population, allowing for its persistence as the source population for all four phases of Chinook salmon restoration in the Elwha River.

The proposed steelhead program will benefit Elwha River steelhead population spatial structure through production of adult fish that would escape to spawn in the areas unused by the species over a century. Hatchery-origin fish escaping spontaneously, hatchery-origin fish trucked upstream and released, and the progeny of these naturally spawning hatchery fish will substantially extend population spatial structure in the watershed relative to levels and capabilities observed for natural-origin steelhead at the present time and as expected in subsequent years.

Improvements in steelhead productivity in previously vacant habitat upstream of the dam sites may be accelerated by adult fish production, escapement, and spawning by hatchery-origin steelhead over the short term relative to reliance on natural-origin fish production only, which is currently at critically depressed levels that are further threatened by dam removal effects. Because the natural population is at very low abudance, the supportive breeding program will enhance the probability of fish finding mates and thus natural productivity is expected to improve, relative to conditions without the supportive breeding program.

The proposed hatchery programs will contribute substantially to marine-derived nutrient input in the Elwha River watershed at levels beneficial to steelhead by increasing the number of naturally-spawning salmonid carcasses and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase productivity in the watershed, enhancing food resources for naturally produced steelhead. Approximately 70 miles of habitat upstream of RM 5 in the Elwha River has been starved of marine derived nutrients for 100 years through preclusion of anadromous fish spawning above the dams. The productivity of steelhead in the Elwha River watershed above RM 5 would particularly benefit from implementation of the programs, as anadromous salmonids, which historically provided carcasses before the dams were constructed, would return as a source of marine derived nutrients through upstream releases of adult hatchery-origin fish and through spontaneous escapement after anadromous fish access is restored in 2013.

Long Term Effects on Recovery

NMFS' evaluation of the effects of the proposed supportive breeding programs on listed steelhead addresses, to the best of its abilities, effects expected over the longer term, and spanning all four phases of fish restoration. Expected risk and benefit effect levels for Elwha River native steelhead for the intitial two phases of restoration – the preservation and recolonization phases – have less uncertainty than effects expected for the latter local adaptation and self-sustaining phases. Reasonable expectations can be appied regarding the current and near-term future viability status of the population, and the condition and productivity status of watershed habitat affected by dam removal activities, for these initial phases, as can the performance and effects of the supportive breeding program.

However, there is greater uncertainty regarding the latter phases of restoration. There has never been a project of the magnitude of the Elwha River dam removal effort to serve as a template to estimate future effects with great certainty. The expected dynamic and largely unpredictable nature of natural and hatchery steelhead survival and productivity, watershed habitat condition and productivity, and scientific uncertainty regarding the pace of watershed recovery from dam removal effects, add to this uncertainty. Nevertheless, it is feasible to reach broad effects conclusions regarding supportive breeding program effects on rcecovery over the longer term considering the specific actions proposed to minimize risks, and impart benefits, and how these risks and benefits would affect listed steelhead in the latter phases of restoration.

A primary supportive breeding effect carried forward over the longer term and across the latter phases of restoration is preservation of the Elwha River steelhead population (LEKT 2012a). As described above, NMFS concludes that the supportive breeding program for the species will preserve an already critically small population during a period when watershed conditions are inhospitable to natural steelhead survival and productivity. Lacking the supportive breeding program, the population will be at risk of extirpation. Implementation of the program will sustain the genetically unique, native steelhead that has evolved within the watershed so that it is available to locally adapte and become self-sustaining over the longer term. Without the supportive breeding program for the species, it is likely that there would be no native population remaining to benefit restoration in the latter phases. Benefits afforded by the program to total population abundance and natural steelhead viability will be monitored throughout the four restoration phases to ensure the supportive breeding effort is assisting restoration, as evaluated in the preceding sections.

Conclusions regarding the demographic, genetic, and ecological risks to listed Chinook salmon described in this section can reasonably be assumed to apply over the longer term as worse case outcomes for the following reasons. Risks posed by the supportive breeding programs are assessed based on current juvenile and adult hatchery fish production levels. In the preceding sections, NMFS concludes that risks associated with the programs as described in the HGMPs will not substantially affect listed steelhead. The program is implemented applying measures that will reduce the risk of adverse effects on listed steelhead. Monitoring and evaluation actions will be implemented to identify program performance in meeting steelhead resatoration objectives.

Over the longer term, as the steelhead population meets viability triggers for each restoration phase (Table 4), as identified through monitoring and evaluation of steelhead status, the program will be adjusted accordingly, and risks will be reduced relative to those assessed under the proposed HGMP. For example, when steelhead population viability triggers for the restoration phase are met, and the status of the natural steelhead population improves, the number of supportive breeding program-origin adult fish spawning naturally will be reduced. This reduction will occur through decreases in the number of juvenile fish released, and/or removal of adult hatchery fish from the river. These responsive program adjustment acitons will result in reductions in the genetic and ecological effects determined as unsubstantial at current hatchery fish production levels. As the status of natural steelhead improves into the self-sustaining phase of restoration, consistent with criteria in Table 4, no hatchery fish will be needed for natural spawning to sustain the Elwha River steelhead population at a viable level, and the program will be terminated. Any risks associated with supportive breeding identified for the proposed actions in this opinion will therefore be entirely removed. The need to terminate the program would be consistent with NMFS population viability and delisting criteria, as populations relaint on artificial propagation are not viable, and can not be considered recovered until supportive breeding actions are phased.

In summary, it is NMFS' assessment that the Elwha River steelhead population will benefit over the longer term, and across all four restoration phases, as a result of preservation and recolonization assistance afforded by the supportive breeding program. The population will be better off with the program, relative to no program at all, because the population would be placed at risk of extirpation lacking supportive breeding when watershed conditions are inhospitable, making the population unavailable for restoration of the species over the longer term. Risks assessed for the program and determined to be unsubstantial in effect on listed steelhead in this opinion represent worst case outcomes for the latter restoration phases. Risk levels will be further reduced as adult escapement and juvenile release numbers are adjusted downward.

Although the latter two phases have been generally evaluated for effects of the entire proposed action, due to uncertainty regarding future conditions and effects, consultation will need to be reinitiated for the local adaptation and full restoration phases to ensure full compliance with the ESA.

NMFS has determined that the potential negative impacts on natural-origin Puget Sound steelhead would be adequately minimized through the proposed actions, that these impacts would not rise to the level of a serious adverse effect on the entire DPS, and that these effects would be sufficiently monitored to determine if further action is needed. Based on the effects conclusions presented above, the risk to survival and recovery of this species will be reduced through implementation of the supportive breeding program. The analysis above has considered recovery planning documents and the potential effects of the proposed propagation programs on the listed Elwha River steelhead population, combined with other ongoing activities within the action area, and determined that the proposed hatchery programs would not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the Puget Sound steelhead DPS or the Elwha River winter-run population component of the DPS.

2.6.3. Eulachon

The effects of the proposed Elwha River salmon and steelhead HGMPs described in section 2.4 would not generally be expected to appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the southern DPS of Pacific eulachon. The potential ways that the proposed hatchery programs could impact listed eulachon in the action area are through facility operation (groundwater withdrawals and effluent discharge), ecological effects (competition and predation), and monitoring and evaluation effects (methodology impacts). Other effects previously evaluated and authorized through separate NMFS ESA consultation processes (NMFS 2010b), are included in the environmental baseline of this opinion.

Facility operation effects, including groundwater withdrawal and hatchery effluent discharge impacts, for the five proposed hatchery programs on eulachon will be unsubstantial. Groundwater withdrawal levels to support the hatchery operations will be very small relative to the total volume of water available for listed fish production in the Elwha River. Hatchery effluent discharge is not a risk to eulachon and will be regulated under federal NPDES permits to ensure that downstream aquatic life, including rearing and migrating eulachon, would be adequately protected from adverse water quality impacts.

Competition for food, space and resources with fish produced through the supportive breeding programs will not adversely impact eulachon. There will be little or no co-occurrence that would lead to competitive interactions between hatchery-origin fish and rearing and migrating eulachon because of the mid to late-spring release timings for the hatchery fish. Because of severely limiting habitat conditions and the observed very low abundance of eulachon in the basin, there are expected to be few eulachon in the watershed that would be affected by competition with hatchery-origin fish. The duration of any interactions, and spatial and temporal overlap between the species that might cause competitive interactions will be limited through release of all juvenile hatchery-origin fish only as seaward migrating smolts and only directly from the hatcheries located in the lowest portions of the watershed. On-station hatchery fish releases will largely occur during months when eulachon have not been observed to be present in the Elwha River. Risk management measures are proposed for implementation in the five proposed hatchery plans to minimize competition risks to natural-origin species, including eulachon.

Predation by fish produced through the proposed hatchery programs is not expected to adversely impact listed eulachon. The only life stage of the species identified in the Elwha River has been adults, and their average individual size (166 mm for females and 180 mm for males) is too large for consumption by any of the newly released juvenile hatchery-origin fish species. Also, there will be little interaction or co-occurrence between hatchery-origin fish and eulachon because of the very low observed abundance status of the forage fish species and adverse habitat conditions, that will limit the success of any reproduction of eulachon that may be affected by predation during the preservation and recolonization phases. Hatchery fish will be released in mid to late-spring as juveniles only as seaward migrating smolts and only directly from the hatcheries located in the lowest portions of the watershed, limiting the duration and areal extent of interactions with any eulachon present in the river. Adequate risk reduction measures are proposed for implementation in the hatchery plans to minimize predation risks to listed eulachon.

Effects from proposed salmon and steelhead monitoring and evaluation activities will not adversely affect eulachon, because a substantial proportion of the actions will take place within the hatchery environment where no eulachon are present. Monitoring and evaluation actions occurring in the natural environment will occur during the summer-fall-winter adult salmon and steelhead spawning migration periods, when no migrating, gravid eulachon have been observed in the river.

2.6.4. Critical Habitat

Critical habitat for the listed species, where designated, is described in section 2.4.4. The action area included the portions of the Elwha River watershed that have been designated as essential for spawning, rearing, juvenile migration, and adult migration of listed Puget Sound Chinook salmon and eulachon. Although critical habitat has not yet been designated for Puget Sound steelhead, the critical habitat area, features and PCEs defined for Chinook salmon are assumed to adequately reflect parameters important for steelhead in the Elwha River.

Operation of the hatchery programs is not expected to substantially impact PCEs within the action area. Hatchery facilities are either located high in the floodplain, or are protected by dikes authorized previously through other ESA consultations (NMFS 2006a), and have not led to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment, or the loss of habitat diversity. Effects on water quantity and water quality are not significant.

The hatchery facilities are designed and will be used such that they would not reduce access to spawning and rearing habitat, or increase water temperatures. Potential impacts on critical habitat evaluated for Puget Sound Chinook salmon and eulachon were limited to competition for freshwater spawning sites from hatchery-origin adults and their progeny, and competition for freshwater rearing sites from juvenile fish released from the programs and the progeny of naturally spawning hatchery-origin adults. However, the design of the hatchery programs will limit co-occurrence of hatchery and natural-origin fish, and the programs will be operating at a time when critical habitat will benefit from the recolonization of 70 miles of newly-accessible Chinook habitat. Therefore, any impacts t critical habitat from competition and predation will be minimized in significance by this expansion and what it means to Chinook salmon.

In reviewing the proposed action and the effects analysis NMFS has determined that the five proposed hatchery programs will not impact habitat designated as essential for spawning, rearing, juvenile migration, and adult migration in the action area.

2.6.5. Climate Change

The Elwha River Chinook salmon, steelhead, and eulachon populations may be adversely effected by climate change (see section 2.4.5). A decrease in winter snow pack resulting from predicted rapid changes over a geological scale in climate conditions on the Olympic Peninsula would be expected to reduce spring and summer flows, impairing water quantity and water quality in primary fish rearing habitat located in the mainstem Elwha River, including upriver areas that would become newly accessible to anadromous fish populations after 2013. Predicted increases in rain on snow events would increase the frequency and intensity of floods in the mainstem river, leading to scouring flows that would threaten the survival and productivity of natural-origin listed species. The proposed hatchery programs are expected to help attenuate these impacts over the very short term by providing refuges from adverse effects for the propagated species through circumvention of potentially adverse natural spawning, incubation, and rearing conditions.

2.6.6. Summary

After evaluating the effects of the supportive breeding programs on listed species within the action area, NMFS has determined that, on balance, the effects on listed salmon and steelhead are beneficial, that the effects on eulachon are limited to potentially impacting individuals within the populations annually, and that such impacts would not be expected to accumulate over time.

As described above, the proposed action covers continued operation of the five hatchery programs over the initial phases of fish restoration in the Elwha River – the preservation and recolonization phases – with transitions between phases gauged by achievement of population viability parameters for listed Chinook salmon and steelhead set forth by the EMG (EMG 2012) and summarized in Tables 3 and 4 in this opinion. Over a longer period of time (i.e., extending into the local adaptation and self-sustaining population phases of restoration), NMFS expects that changes in the status of the listed populations, changes in lower river and estuary habitat as the watershed recovers post-dam removal, and changes in the environment due to climate change will lead to a reevaluation of the proposed programs and their effects on listed species pursuant to NMFS regulations at 50 CFR 402.16 (reinitiation of consultation), and reduction and phase-out of all hatchery programs as salmon and steelhead population viability parameters delineating the local adaptation and self-sustaining exploitable population phases, respectively, are achieved.

2.7. Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the Puget Sound Chinook salmon ESU, the Puget Sound steelhead DPS, or the southern DPS of Pacific eulachon, or to destroy or adversely modify their designated critical habitat.

With regards to the actions proposed in the hatchery plans for Chinook salmon (WDFW 2012) and steelhead (LEKT 2012a), we note that supportive breeding of at-risk species has had wide-spread, accepted use, world-wide, and for many decades. Well known examples of such efforts where effective alternatives for saving the species were not available on the short term include supportive breeding-based recovery actions to prevent extinction of the California condor (Snyder 1986; Meretsky et al. 2000); black-footed ferret (Dobson and Lyles 2000); and Redfish Lake sockeye salmon (Flagg et al. 2001). Supportive breeding has been used as a means to preserve, and improve the viability of, these and many other unique animal populations placed at moderate or high risk of extinction by anthropogenic threats, in particular degradation or elimination of natural habitat sustaining the animals. The proposed hatchery plans considered in this opinion would perform the same preservation and population recovery functions for the ESA- listed and non-listed salmonid species in the Elwha River watershed during the preservation and recolonization phases of restoration, and effects in later phases will continue to be risk averse and beneficial. All fish species in the watershed, including listed Chinook salmon and steelhead, have been driven to critically poor viability levels due to long term blockage and degradation of critical habitat by the construction and operation of the Elwha dams. The already depressed populations are now further threatened with extinction from the effects of the release of massive quantities of stored sediments as the dams are removed. NMFS agrees with the conclusions of the HSRG (2012) that the supportive breeding strategies proposed in the HGMPs are likely to be successful at preserving the existing genetic resources of salmon and steelhead throughout the period of adverse habitat conditions during and immediately following dam removal in the Elwha River Basin.

NMFS believes that the Chinook salmon and steelhead supportive breeding programs are important tools to meet preservation and recolonization objectives and to avoid subjecting listed species to unnecessary risks. The need for operation of both programs for stock preservation and recolonization purposes is supported by recent abundance, productivity, and population growth rate trend data for Chinook salmon spawning naturally in the Elwha River. From an analysis of otolith mark recovery data, WDFW estimates that approximately 95% of adults returning to the river from 2008 to 2010 originated from Elwha hatchery programs, and just 4% were of natural-origin (WDFW 2012). Monitoring of natural-origin Chinook salmon productivity in the lower Elwha River for two full brood return years (2004 and 2005) indicated that emigrant juvenile to returning adult fish survival rates for natural-origin Chinook salmon were extremely low: 0.044% and 0.096%, respectively (WDFW 2012). The two brood years contributed only 63 natural-origin, three and four-year old fish to the total escapement to the river in 2008 of 1,153 fish, and 62 four and five-year old adult fish to the 2009 total escapement of 2,181 fish (WDFW 2012). Short term (1995-2009) and longer term growth rates, derived for the Elwha Chinook salmon population assuming much more substantial natural-origin fish return numbers and proportions than shown in new analyses, were below 1.0: 0.973 and 0.934, respectively (NMFS 2011b).

Assuming that these abundance, productivity and growth rate trend data reflect the viability status of the naturally spawning population over the decades since the dams were placed, it is reasonable to conclude that the Elwha Chinook salmon population would be extinct but for supportive breeding provided by annual operation of the proposed Elwha Channel Hatchery program. The projected inhospitable condition of the river for natural-origin fish survival and productivity due to sedimentation and turbidity caused by release of stored sediments behind the dams, and uncertainties regarding natural population productivity and the pace of habitat recovery post-dam removal (Brenkman et al. 2008; Duda et al. 2008), provide further support for the implementation of the proposed hatchery programs. NMFS agrees with Ward et al (2008) that without proactive intervention, the conditions that will be present in the river below the dams during and immediately following dam removal may result in mortality rates approaching 100% for any naturally rearing fish, virtually eliminating local, genetically viable salmon and steelhead brood sources for recolonization. Fish straying from other river systems in the Salish Sea area might repopulate the Elwha watershed over time, but extirpation of remaining native salmon and steelhead populations resulting from dam removal is not an acceptable option, particularly for Elwha Chinook salmon and Elwha native winter-run steelhead that are genetically unique, native populations, essential for the recovery of the entire ESA-listed Puget Sound Chinook salmon ESU and Puget Sound steelhead DPS, respectively. The proposed programs would preserve and help recover what remains of the Elwha River salmon and steelhead populations and set each of the populations on course for recovery.

2.8. Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. For purposes of this consultation, we interpret "harass" to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or significantly altered.[6] Section 7(b)(4) and Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA, if that action is performed in compliance with the terms and conditions of this incidental take statement.

2.8.1. Amount or Extent of Take

Takes of listed Puget Sound Chinook salmon, Puget Sound steelhead, and eulachon would be expected to result from the proposed hatchery programs. The take of these species as a result of the proposed action would potentially occur through (1) facility operation, specifically groundwater withdrawal and hatchery effluent discharge effects on all listed fish species; (2) propagation of Chinook salmon and steelhead in the hatchery environment, causing hatchery-induced selection effects; (3) release of juvenile hatchery fish, and resultant return of hatchery-origin adult fish, leading to outplanting of genetic effects on listed Chinook salmon and steelhead in the wild; (4) ecological effects (competition and predation) impacting all of the listed fish species; (5) harvest impacts on Chinook as a result of adipose fin clipping; (6) broodstock collection, impacting Chinook and steelhead; and (7) methods implemented to conduct monitoring and evaluation of Chinook and steelhead.

[6] NMFS has not adopted a regulatory definition of harassment under the ESA. The World English Dictionary defines harass as "to trouble, torment, or confuse by continual persistent attacks, questions, etc." The U.S. Fish and Wildlife Service defines "harass" in its regulations as an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns, which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). The interpretation we adopt in this consultation is consistent with our understanding of the dictionary definition of harass and is consistent with the U.S. Fish and Wildlife interpretation of the term.

(1) Facility Operation Effects
While minimal effects are expected as discussed above, NMFS believes that groundwater withdrawals and effluent discharges resulting from implementation of the proposed hatchery programs have the potential to cause take of ESA-listed salmon, steelhead and Eulachon in the action area. It would not be possible to accurately assign take of listed species to facility effects, however, since the minimal change in water quality and quantity will be just one factor facing salmonids in the river; nor would it be possible to quantify such take, since the effects of water withdrawals on individual fish cannot be detected and counted. Therefore, NMFS will rely on a surrogate take indicator for both take pathways.

Regarding groundwater withdrawals, the surrogate take indicator is any withdrawal of water by hatchery wells that reduces the flow of the Elwha River by 25 percent of the total flow immediately downstream from the point of groundwater withdrawal. This level has a rational connection to the amount of take because it reflects potential changes to the hydrograph of the Elwha River which, if significant, are likely to result in take of salmonids. This will be measured by the hatchery operators through comparisons of estimated average groundwater withdrawal levels by month in cubic feet per second (cfs) with monthly average river flow estimates for the section of the mainstem river above the point of groundwater removal.

Regarding effluent discharge effects, the surrogate take indicator is any effluent discharge that exceeds any applicable water quality standard or any term of the NPDES permit issued to the LEKT (permit# WAG13-0023) and WDFW (permit #WAG13-1043). This standard has a rational connection to the amount of take because water quality standards are designed to limit discharges into waterways which would result in harm to fish, wildlife and other beneficial uses. This will be measured by compliance by the LEKT and WDFW with NPDES discharge permit standards, gauged through periodic monitoring and reporting (quarterly) of specific water quality parameters at the point of hatchery effluent discharge into downstream waters, consistent with NPDES Permit requirements.

(2)-(3) Genetic Effects
Take of listed Chinook salmon and steelhead is expected to occur (a) as a result of artificial propagation of both species in the hatchery environment, resulting in hatchery-induced selection effects; and (b) as a result of the release of those hatchery-bred fish into the natural environment where they interact with natural-origin Chinook salmon and steelhead, resulting in the outplanting of the hatchery-induced selection effects and the potential outbreeding effects on the genetic diversity and productivity of natural origin fish who interbreed with the hatchery-origin fish. These two take pathways constitute the genetic effects

During the preservation phase of the proposed action, it is possible that up to 100 percent of the listed Elwha Chinook and steelhead populations will experience the genetic effects because listed Chinook salmon and steelhead returning adults will either be taken into the hatchery and exposed to these genetic effects, or moved upstream to spawn naturally along with hatchery-origin fish. In the effects analysis, NMFS determined that genetic impacts to all listed fish will not amount to jeopardy, although in reaching that conclusion we assumed that the impacts would be of a certain magnitude. In this context the appropriate take indicator should reflect the level of harm anticipated as a result of genetic effects.

It would not be possible to accurately measure genetic effects in a way that would allow for the accurate quantification of take, because the genetic effects specified above cannot be detected in a comprehensive, reliable manner. [Tissue sample studies can be used to detect genetic certain trends, but they take several years to complete, making them unfit as a compliance tool.] Therefore, NMFS will rely on a surrogate take indicator that relates to the productivity of the listed populations – the primary factor in determining genetic effects. During the recolonization phase, the productivity goal identified in Tables 3 and 4 above is 1.0 recruits per spawner (post-fishing, in the case of Chinook). The surrogate take indicator, therefore, is a failure to attain a productivity rate of 0.8 recruits per spawner for the Elwha River Chinook salmon and steelhead populations for four consecutive years. Productivity will be monitored by the hatchery operators, by comparing estimated adult Chinook and steelhead escapement to natural spawning areas in the Elwha River watershed fwith resultant returning spawner brood years escapement. For Chinook salmon, FRAM-based estimates of total adult recruitment to fisheries harvest plus escapement would be used to estimate total recruitment for resultant progeny brood years.

This standard has a rational connection to the genetic effects take pathway, for several reasons. First, four consecutive years represents the full life cycle of the species and enables NMFS to detect potential effects above and beyond any single-year anomaly. Secondly, 0.8 recruits per spawner is materially below the stated productivity goal, which would indicate that NMFS' conclusion that genetic effects are not a significant limiting factor would merit reconsideration at that point. It should be noted that the productivity goals may go unmet for a variety of factors, apart from genetic effects, but this indicator would trigger further analysis to determine the causes of low productivity.

There is no potential for genetic effects to cause take of Eulachon.

(4) Ecological Effects - Competition and Predation

NMFS has determined that the proposed action carries a risk of take resulting from ecological hazards: competition between hatchery and natural-origin fish for food and habitat, and predation by hatchery fish on natural-origin fish. These ecological effects posed by the proposed hatchery programs to listed Chinook salmon, steelhead, and eulachon in the action area are anticipated to be minimal over the duration of the preservation and recolonization phases, as described above.

It is not possible to quantify the take associated with competition and predation in the action area, because it is not possible to meaningfully measure the number of interactions between hatchery-reared and natural origin salmon and steelhead, or between hatchery-bred fish and Eulachon. Therefore, NMFS will rely on a surrogate take indicator that relates to the proportion of hatchery fish in the rearing areas of the lower Elwha River. The surrogate take indicator is a proportion of hatchery juvenile salmon and steelhead greater than 10 percent of all hatchery and naturally-produced salmon and steelhead in the rearing areas in the rearing areas downstream of the hatchery release site on or after the 21st day following any release of hatchery fish during the recolonization phase.

This standard has a rational connection to the amount of take expected from ecological effects, since the co-occurrence of hatchery and natural-origin fish is a necessary precondition to competition and predation, and the assumption that the greater ratio of hatchery fish to wild fish, the greater likelihood that competition and predation will occur. This proportion of hatchery fish in the rearing areas will be monitored by standing LEKT juvenile monitoring activities

(5) Harvest Effects
Under the proposed action, an adipose fin-clip mark will be applied to all yearling fish and to as many as 250,000 subyearling Chinook salmon beginning no earlier than in release year 2016. Providing an adipose fin-clip mark increases the likelihood that an individual salmon will be harvested at sea, since unmarked fish are more likely to be released when caught. WDFW calculates that this action would likely result in a reduction in the total abundance of adult fish escaping to spawn in the river each year relative to the escapement level that would result from the release of unmarked fish groups. As estimated by FRAM exploitation rate comparisons, WDFW proposes that increased interceptions of Elwha River hatchery-origin Chinook salmon in mark-selective fisheries allowing retention of adipose fin-clipped fish may result in the additional take of 48 fish per year, reducing annual escapement to the river by 2.8% (WDFW 2012). Therefore, the extent of take of Elwha River Chinook salmon anticipated as a result of the adipose fin-clip marking of hatchery Chinook is 48 fish per year.

To verify these estimates, WDFW will release a sub-group of 250,000 subyearlings in 2013 marked with an adipose fin clip-coded wire tag combination to allow for assessment of actual fisheries interception rates for adipose fin clipped Elwha Chinook salmon. Fisheries exploitation rates and take levels that may result from fisheries harvest will be monitored throughout the proposed action by WDFW and the LEKT using the FRAM and through spawner abundance surveys and estimates. No take of Eulachon results from marking of Chinook.

(6) Broodstock Collection
Up to 1,700 listed adult Chinook salmon and 500 listed adult steelhead will be collected each year for use as broodstock at the hatchery weirs and traps, the mainstem Elwha River weir, and through in-river methods including seining, gillnetting and gaffing. Therefore, the expected take by capture, handling and sampling during broodstock collection is 1700 Chinook salmon and 500 steelhead. Monitoring of take levels for broodstock collection actions will occur through hatchery operator observation and recording of daily and cumulative adult Chinook salmon and steelhead removal levels for all broodstock collection activities. No take of Eulachon occurs as a result of broodstock collection.

(7) Monitoring and Evaluation
Take may occur in connection with the monitoring and evaluation actions included in the proposed action. Marking and/or tagging of all juvenile Chinook salmon and steelhead reared and released through the hatchery programs to allow for assessment of hatchery program performance and effects is expected to take up to 2.9 million listed Chinook salmon and 175,000 listed native stock steelhead each year. Sampling of Chinook salmon and steelhead reared in the hatchery and prior to their release for fish health monitoring purposes would lead to the handling, injury and mortality of a small (e.g., 60 juvenile and 60 adult fish) subset of the total number of

fish produced each year. In annual reports required by NMFS, takes associated with the monitoring and evaluation projects will be identified so that the effects on listed species can be monitored. No take of Eulachon results from these monitoring and evaluation activities.

2.8.2. Effect of the Take

In section 2.7, NMFS determined that the level of anticipated take, coupled with other effects in the proposed action, is not likely to jeopardize the continued existence of Puget Sound Chinook, Puget Sound steelhead, Pacific Eulachon, or adversely modify designated critical habitat for Puget Sound Chinook salmon or Pacific Eulachon.

2.8.3. Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). "Terms and conditions" implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in section 7(o)(2) to apply. NMFS may amend the provisions of this incidental take statement after giving the LEKT and WDFW reasonable notice of the amendment.

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize the impacts from the proposed hatchery programs on the Puget Sound Chinook salmon ESU, Puget Sound Steelhead DPS, and Southern DPS of Pacific Eulachon:

1. The Action Agencies must ensure implementation of the hatchery programs as described in the submitted HGMPs as proposed for the duration of the preservation and recolonization phases of fish restoration.
2. The Action Agencies must ensure that LEKT and WDFW manage their operations to limit the risk of adverse demographic, ecological, and genetic effects on listed Puget Sound Chinook salmon.
3. The Action Agencies must ensure that LEKT and WDFW manage their operations to limit the risk of adverse demographic, ecological, and genetic effects on listed Puget Sound steelhead.
4. The Action Agencies must ensure that LEKT and WDFW manage their operations to limit the risk of adverse demographic and ecological effects on listed eulachon.
5. The Action Agencies must ensure that LEKT and WDFW follow criteria and guidelines specified in this opinion for their respective hatchery facilities, including associated broodstock collection and juvenile and adult fish release locations.
6. The Action Agencies must ensure that LEKT and WDFW follow criteria and guidelines specified in this opinion for their respective monitoring and evaluation activities within the Elwha River Basin.
7. The Action Agencies must ensure that LEKT and WDFW provide reports to the NMFS Salmon Management Division (SMD) annually for all hatchery programs, and for all research, monitoring, and evaluation activities associated with the hatchery programs.

8. The Action Agencies must ensure that LEKT and WDFW comply with all of the ESA requirements and provisions in the Incidental Take Statement.

2.8.4. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Action Agencies must ensure that the compliance with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary with respect to species listed under the ESA.

1a. The Action Agencies must ensure implementation of the hatchery programs as described in the submitted HGMPs for the terms of the preservation and recolonization phases of fish restoration only. These two phases are defined for the purposes of this opinion in Section 1.2. NMFS' SMD must be notified, in advance, of any change in hatchery program operation and implementation that potentially would result in increased take of ESA-listed species.

1b. The Action Agencies must ensure that LEKT and WDFW maintain levels of hatchery-origin juvenile and adult salmon and steelhead production up to the levels proposed in the HGMPs to the extent feasible for the duration of the preservation and recolonization phases to help ensure that remnant native populations are preserved and enhanced to improve future prospects for meeting population viability parameters for the local adaptation and self-sustaining exploitable population phases of restoration.

1c. The Action Agencies must ensure that LEKT and WDFW adjust supportive breeding actions described in the HGMPs, including juvenile and adult fish release levels and locations, and adult fish broodstock collection levels, based on achievement of the specific population viability parameter triggers identified for each restoration phase, as summarized in Tables 3 and 4 of this opinion from the Monitoring and Adaptive Management Plans for Elwha River Chinook salmon and steelhead (EMG 2012; 2012b). In general, achievement of the triggers identified in the plans shall direct the need to transition between restoration phases, and adjust supportive breeding actions and escapement management actions accordingly.

1d. The Action Agencies must ensure that LEKT and WDFW prepare for transition from the recolonization phase to the local adaptation phase of restoration by taking actions consistent with achievement of triggers for the two phases, as the natural-origin listed Chinook salmon and steelhead populations meet population viability criteria identified by the Elwha Monitoring Group for the phases (EMG 2012; 2012b; summarized in Tables 3 and 4 of this opinion).

1e. The Action Agencies must ensure that LEKT and WDFW maintain on-station releases of juvenile salmon and steelhead, consistent with abundance levels described in the proposed HGMPs, as the primary hatchery fish release strategy applied during the preservation and recolonization phases. Upstream transport and release for natural spawning of adult fish shall be applied as the secondary hatchery fish release strategy during the preservation phase, and the tertiary strategy, behind spontaneous natural escapement and spawning by returning adult fish, during the recolonization phase.

1f. The Action Agencies must ensure that LEKT and WDFW mark and/or tag all hatchery-origin juvenile salmon and steelhead released each year through the hatchery programs as described in the HGMPs to allow for the differentiation of hatchery- and natural-origin juvenile and adult fish in the natural environment, assessment of hatchery program effects on listed fish, and evaluation of program performance in meeting HGMP objectives.

1g. The Action Agencies must ensure that LEKT and WDFW review annually the status of the Elwha River Chinook salmon and steelhead populations relative to population viability parameter triggers identified for each restoration phase to guide decisions regarding transition between the preservation, recolonization, and local adaptation phases, and responsive adjustment or phase out of supportive breeding actions for the listed species.

1h. The Action Agencies must ensure that LEKT and WDFW submit an Annual Operation Plan to the NMFS SMD for the following year that is consistent with the terms and conditions within this incidental take statement and designed consistent with information on program performance and the standing of supportive breeding actions relative to fish restoration phases provided by monitoring data.

2a. The Action Agencies must ensure that LEKT and WDFW monitor and evaluate the performance and effects of the programs, and manage the programs in response to findings, to meet program objectives while minimizing impacts on listed Puget Sound Chinook salmon. Monitoring and evaluation actions shall concentrate on collection and analyses of data necessary to identify the status of the Elwha Chinook salmon population relative to population viability parameter triggers defined for each restoration phase in Table 3 of this opinion. The supportive breeding programs shall be adjusted in response to monitoring and evaluation data indicating achievement of all of the viability triggers for each restoration phase summarized in Table 3.

2b. The Action Agencies must ensure that LEKT and WDFW monitor the annual abundance, timing, distribution, and origin of Chinook salmon adults escaping to the Elwha River watershed above and below the dam sites using methods sufficient to provide estimates of the status of the natural- and hatchery-origin components of the population, proportions of the population by origin escaping to the river above and below the dam sites, relative contribution of natural- and hatchery-origin fish to natural spawning, and the effects of supportive breeding actions in meeting restoration objectives.

2c. The Action Agencies must ensure that LEKT and WDFW monitor the annual abundance, timing, life history stage, and origin of Chinook salmon juveniles emigrating seaward from production areas in Elwha River watershed above and below the dam sites using methods sufficient to derive estimates of the productivity status of the naturally produced component of the population, migrational overlap and behavior of natural- and hatchery-origin fish, and the effects of supportive breeding actions in meeting restoration objectives.

2d. The Action Agencies must ensure that WDFW not apply an adipose fin clip mark to more than 250,000 juvenile Chinook salmon released through the Elwha Channel Hatchery program each year if the average observed fisheries exploitation rate in all adipose mark-selective fisheries is shown to be greater than 5.0%, as estimated by NMFS' exploitation rate analysis of 2012 and 2013 brood year adipose clipped, coded-wire tagged subyearling Chinook salmon release sub-groups. Until the exploitation rate analysis of the 2012 and 2013 brood subyearling coded-wire tagged Chinook salmon is completed (based on projected availability of required CWT recovery data for the two brood years, earliest exploitation rate analysis completion year would be 2018), adipose fin clip mass marking of the remainder of the juvenile Chinook salmon released through the program shall not occur and other means to differentiate hatchery-origin fish will continue to be used, such as otolith marking or wire tagging without an adipose fin clip of all fish released. The intent is that the total annual escapement of Chinook salmon to the river would be reduced by no more than 2.8% as a consequence of estimated additional mark-selective fishery impacts if *all* Elwha Channel Hatchery program production was mass-marked with an adipose fin clip.

2e. The Action Agencies must ensure that WDFW monitor and report relative fisheries and escapement contribution proportions for mass adipose fin clip-marked Elwha Channel Hatchery program-origin subyearling Chinook salmon sub-groups on an annual basis consistent with the reporting requirements described elsewhere in the Terms and Conditions as a means to indicate the potential effects of a 100% adipose fin clip marking strategy on the total abundance of fish escaping to the river.

2f. In combination with the information described in 2d and 2e above, the Action Agencies must ensure that WDFW take into account the current escapement abundance status of the total Elwha River Chinook salmon return relative to abundance triggers included in Table 3 of this opinion. These triggers are subject to adjustment, when appropriate, as population-specific data regarding Elwha Chinook salmon survival and recruitment rates become available, and following the decision-making approach specified in the Chinook salmon MAMP (EWG 2012). The standing or adjusted abundance triggers set for the preservation and re-colonization phases shall be used to guide the timing for application of a mass adipose fin clip mark for subyearling Chinook salmon released through the Elwha Channel Hatchery program. Adipose fin clip marking of all sub-yearlings will be delayed if NMFS determines that total fisheries impact levels estimated from subyearling Chinook salmon sub-group coded wire tag recoveries would slow progress in achieving agreed abundance triggers for the preservation and re-colonization phases relative to fisheries impact outcomes resulting from other hatchery-origin fish marking strategies.

3a. The Action Agencies must ensure that LEKT and WDFW monitor and evaluate the performance and effects of the programs, and manage the programs in response to findings, to meet program objectives while minimizing impacts on listed steelhead.

Monitoring and evaluation actions shall concentrate on adequate collection and analyses of data necessary to identify the status of the Elwha River steelhead population relative to population viability parameter triggers defined for each restoration phase in Table 4 of this opinion. The supportive breeding programs shall be adjusted in response to monitoring and evaluation data indicating achievement of all of the viability triggers for each restoration phase summarized in Table 4.

3b. The Action Agencies must ensure that LEKT and WDFW monitor the annual abundance, timing, distribution, and origin of steelhead adults escaping to the Elwha River watershed above and below the dam sites using methods sufficient to provide estimates of the status of the natural- and hatchery-origin components of the population, proportions of the population by origin escaping to the river above and below the dam sites, relative contribution of natural- and hatchery-origin fish to natural spawning, and the effects of supportive breeding actions in meeting restoration objectives.

3c. The Action Agencies must ensure that LEKT and WDFW monitor the annual abundance, timing, life history stage, and origin of steelhead juveniles emigrating seaward from production areas in Elwha River watershed above and below the dam sites using methods sufficient to derive estimates of the productivity status of the naturally produced component of the population, migrational overlap and behavior of natural- and hatchery-origin fish, and the effects of supportive breeding actions in meeting HGMP objectives.

3.d The Action Agencies must ensure that LEKT continue to remove hatchery-origin Chambers Creek steelhead from the Elwha River through directed fisheries, consistent with past authorizations, and remove any Chambers Creek steelhead encountered at weirs and traps or at the hatchery.

3e. For all years when fisheries directed at hatchery-origin Chambers Creek steelhead are implemented, the Action Agencies must ensure that LEKT provide monthly steelhead fishery reports through the duration of the season by the 10th working day of the following month to NMFS. The reports shall summarize the al harvest activities, including effort, the number of natural-origin and hatchery-origin steelhead encountered, the number harvested, and estimated total steelhead mortality impacts. A final report describing fishery impacts on listed steelhead by month and fishing area shall be submitted to NMFS by November 30th of the year the fishery was concluded.

4a. The Action Agencies must ensure that LEKT and WDFW monitor and evaluate the performance and effects of the programs, and manage the programs in response to findings, to meet program objectives while minimizing impacts on listed eulachon.

4b. The Action Agencies must ensure that LEKT and WDFW monitor the migration timing and behavior of hatchery-origin salmon and steelhead released during the late winter and early spring months into the lower river through the programs using methods sufficient to estimate the degree of spatial and temporal overlap with any eulachon that are present in the lower river.

5a. The Action Agencies must ensure that broodstock collection actions directed at, or incidentally affecting listed Chinook salmon, steelhead, and eulachon shall be conducted consistent with previous NMFS ESA consultation requirements and listed fish take allowances specified in NMFS (2012a).

5b. The Action Agencies must ensure that water withdrawal actions and methods shall be via structures that meet or exceed NMFS water intake screening criteria. Water withdrawals shall not exceed levels permitted by any Water Use Permits issued to each of the hatchery facilities.

5c. The Action Agencies must ensure that groundwater withdrawals at the hatcheries do not reduce the flow of the Elwha River by 25 percent of the total flow immediately downstream from the point of groundwater withdrawal. Compliance with this condition will be measured by the hatchery operators through comparisons of estimated average groundwater withdrawal levels by month in cubic feet per second (cfs) with monthly average river flow estimates for the section of the mainstem river above the point of groundwater removal.

5d. The Action Agencies must ensure that LEKT and WDFW handle listed fish with extreme care and maintain any listed fish handled in cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that captures a mix of species, the permit holder must process listed fish first, whenever possible, to minimize handling stress.

5e. The Action Agencies must ensure that LEKT and WDFW allow any NMFS employee or representative to inspect any records or facilities related to hatchery program monitoring, evaluation, and research activities.

6b. The Action Agencies must ensure that LEKT and WDFW do not intentionally kill or cause to be killed any listed species unless the incidental take statement specifically allows intentional lethal take.

6c. The Action Agencies must ensure that if the LEKT and WDFW anesthetize listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

6d. The Action Agencies must ensure that LEKT and WDFW use a sterilized needle for each individual injection when passive integrated transponder tags (PIT-tags) are inserted into listed fish.

6e. The Action Agencies must ensure that if the LEKT and WDFW unintentionally capture any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.

6f. The Action Agencies must ensure that LEKT and WDFW exercise care during spawning ground surveys to avoid disturbing listed adult salmonids when they are spawning. Researchers must avoid walking in salmon streams whenever possible, especially where listed salmonids are likely to spawn. Visual observation must be used instead of intrusive sampling methods, especially when just determining fish presence.

6g. The Action Agencies must ensure that LEKT and WDFW, when using backpack electrofishing equipment, comply with NMFS' Backpack Electrofishing Guidelines (June 2000) available at *http://www.nwr.noaa.gov/ESA-Salmon-Regulations-Permits/4d-Rules/upload/electro2000.pdf.*

6h. The Action Agencies must ensure that LEKT and WDFW obtain approval from NMFS before changing sampling locations or research protocols.

6i. The Action Agencies must ensure that LEKT and WDFW be responsible for any biological samples collected from listed species as long as they are used for research purposes. The Action Agencies must ensure that LEKT and WDFW not transfer biological samples to anyone not listed in the HGMPs without prior written approval from NMFS.

6j. The Action Agencies must ensure that the person(s) actually conducting monitoring and research addressed in this opinion shall carry a copy of this incidental take statement while conducting the authorized activities.

6k. The Action Agencies must ensure that LEKT and WDFW allow any NMFS employee or representative to accompany field personnel while they conduct the research activities.

6l. The Action Agencies must ensure that LEKT and WDFW obtain all other Federal, state, and local permits/authorizations needed for the research activities.

7a. All reports, as well as all other notifications required in the permit, be submitted to NMFS at:

NMFS - Salmon Management Division
Production and Inland Fisheries Branch
1201 N.E. Lloyd Boulevard, Suite 1100
Portland, Oregon 97232
Phone: (503) 230-5427
Fax: (503) 872-2737

7b. The Action Agencies must ensure that SMD is notified, as soon as possible, but no later than two days, after any authorized level of take is exceeded or if such an event is likely. This includes the take of any ESA-listed species not otherwise included in this incidental take statement. LEKT and WDFW shall submit a written report detailing why the authorized take level was exceed or is likely to be exceeded.

7c. The Action Agencies must ensure that LEKT and WDFW provide SMD, by October 1 of each year, a monitoring and evaluation project operating plan for the coming year.

7d. The Action Agencies must ensure that LEKT and WDFW provide annual reports to SMD that summarize numbers, pounds, dates, tag/mark information, locations of artificially propagated fish releases, results of monitoring and evaluation activities that occur within the hatchery environment, and adult return numbers by fish origin to any naturally spawning area and to the hatchery program. Reports shall also include any analyses of fisheries harvest rate impacts, including impacts associated with Chinook salmon marking strategies; analyses of scientific research data; any problems that may have arisen during conduct of the authorized activities; a statement as to whether or not the activities had any unforeseen effects; and steps that have been and that will be taken to coordinate the research or monitoring with that of other researchers. These annual reports can include, but are not limited to, reports provided to NPS, USGS, USFWS, and NMFS NWFSC. The reports shall be submitted to SMD by January 31st of the year following juvenile fish releases (e.g., brood year 2011, release year 2012, report due January 2013), or as soon thereafter as the reports providing the necessary information are available.

8a. The Action Agencies must ensure that LEKT and WDFW, in effectuating the take authorized by this incidental take statement, are considered to have accepted the terms and conditions set forth herein and must be prepared to comply with the provisions of this incidental take statement, the applicable regulations, and the ESA.

2.9. Conservation Recommendations

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

1. The LEKT and WDFW should investigate additional methods to externally mark and/or internally tag hatchery-origin salmon and steelhead to ease monitoring and evaluation of hatchery-origin and natural-origin fish survival, productivity, and behavior without substantially increasing risks for the listed species, including harvest impacts, above previously evaluated or authorized levels,.
2. The LEKT and WDFW should continue to improve anadromous fish habitat within the lower Elwha River and estuary areas to support and accelerate recovery of properly functioning habitat processes and conditions that would help foster the establishment of viable Chinook salmon and steelhead populations.
3. The LEKT and WDFW should investigate the level of ecological interactions between hatchery-produced salmon and steelhead and listed fish populations within the Elwha River watershed to identify additional methods to minimize any adverse effects from interactions.

2.10. Reinitiation of Consultation

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

The LEKT and WDFW may immediately request reinitiation of section 7 consultation in instances where it is determined that the amount or extant of take considered in this opinion is exceeded. If there is information indicating that genetic or ecological impacts, beyond those considered in this opinion, are occurring from the operation of the proposed hatchery programs that would be considered a reinitiation trigger under (2) above. Once reinitiation is requested, the Salmon Management Division will consult with the LEKT and WDFW to determine specific actions and measures that can be implemented to address the take or, if required, implement further analysis of the impacts on listed species from the higher level of take.

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

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

This analysis is based, in part, on descriptions of EFH for Pacific coast salmon (PFMC 2003) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

The proposed action is authorization for takes under the ESA of five hatchery programs rearing salmonids for Elwha River salmon and steelhead population preservation and restoration purposes, as described in detail in section 1.3, above. The action area of the proposed action includes habitat described as EFH for Chinook, coho, and pink salmon. Because EFH has not been described for steelhead, the analysis of this section is restricted to the effects of the proposed action on EFH of the three aforementioned Pacific salmon species.

Freshwater EFH for Pacific salmon, as described by the PFMC (2000) includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable manmade barriers, and long-standing, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years). The Elwha River above the Elwha and Glines Canyon Dams has been designated EFH for Chinook, coho, and pink salmon. Assessment of the potential adverse effects on these species' EFH from the proposed action is based, in part, on these descriptions and on information provided by the U.S. Army Corps of Engineers. The EFH species are identified in the Appendix Table 3

The area affected by the proposed action includes, for purposes of hatchery facility operation effects on adult and juvenile Chinook, coho, and pink salmon, the Elwha River watershed, the Elwha River estuary, and the nearshore marine area adjacent to the river mouth (see Figure 1, above).

As described by PFMC (2003):

> "Freshwater EFH for [C]hinook, coho, and pink salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat."

The aspects of EFH that might be affected by the proposed action include effects of hatchery operations on adult and juvenile fish migration corridors in the Elwha River, and ecological interactions and genetic effects in Chinook, coho, and pink salmon spawning areas in the Elwha River, and ecological effects in rearing areas for the species in the Elwha River, its estuary, and in adjacent nearshore marine areas.

3.2. Adverse Effects on Essential Fish Habitat

The proposed action generally does not have effects on the major components of EFH. Spawning and rearing locations and adult holding habitat are not expected to be affected by the operation of the hatchery programs, as no modifications to these areas would occur, and no structures that would impede migration are to be constructed to accomplish the proposed actions. Potential effects on EFH associated with implementation of the proposed action are only likely to occur as a result of hatchery water withdrawal from the Elwha River on juvenile and adult migration corridors. Surface water supplying the hatcheries is provided through newly constructed diversion and intake facilities in the Elwha River collectively referred to as the Elwha Surface Water Intake (ESWI). Surface water withdrawal through the ESWI in support of the Elwha Channel and Lower Elwha Fish hatchery operations considered in this opinion were previously evaluated for effects on EFH through a separate EFH consultation with the National Park Service for the Elwha dam deconstruction project (NMFS 2006a). NMFS concluded that EFH for Pacific salmon would experience adverse effects from the proposed action in total, predominantly resulting from the release of stored sediments behind the dams as they are removed. Models predicted these adverse effects would last for three to five years after the dams have been removed, when water quality would be inimical to salmon. However, NMFS concluded that once the period of high sediments inputs had passed, the proposed action would have lasting beneficial effects on Pacific salmon EFH, and that actions implemented to protect and enhance Chinook salmon designated critical habitat will similarly benefit salmon EFH (NMFS 2006a). NMFS reasonably expected that coho and pink salmon EFH would increase in aerial extent and function over time as a result of the proposed, interrelated and interdependent actions. A subset of ESA Terms and Conditions included in NMFS (2006a) pertaining to surface water withdrawal structure design and operation were determined as necessary measures to avoid, mitigate, or offset impacts of the proposed action:

- The fish diversion screen for the water withdrawal and treatment facility should be properly maintained and functioning to preclude juvenile fish from entering the municipal water supply pipeline and remove from their EFH;
- Professional biologists should monitor the engineered riffle to ensure it provides unimpeded upstream and downstream passage for adult and juvenile PS Chinook salmon and unobstructed downstream delivery of fluvial materials and organic debris; and
- Riprap for required bank stabilization on the west bank of the Elwha River, starting at the engineered riffle and ending downstream where the flood plain narrows and bedrock on

the left bank is exposed, NPS should seek to incorporate alternative bank stabilization measures that enhance fish habitat.

The PFMC (2003) recognized concerns regarding the "genetic and ecological interactions of hatchery and wild fish … [which have] been identified as risk factors for wild populations." The biological opinion describes in considerable detail the specific hazards the proposed hatchery programs might pose to natural-origin fish populations (Section 2.4.1.1). General details regarding risks of hazards to natural-origin fish populations for hatchery programs can be found in NMFS (2012b). In addition to the effects on habitat resulting from hatchery operation effects on water quality and quantity (discussed above), hatchery related effects that might bear on habitat condition may include exceeding the habitat carrying capacity of the natural populations, with adverse effects resulting from increased competition for spawning areas, rearing space, and juvenile feeding by hatchery-origin fish. The proposed action is not expected to result in increases in numbers of hatchery-origin adults or juveniles in natural spawning areas to the extent that the carrying capacity of lower river and newly accessible upper river habitat is exceeded for any fish species over the term of this opinion. With a primary focus on on-station releases of hatchery fish, adults produced through the programs would return primarily to the hatcheries, and would not compete for space with natural fish. Consistent with the intent to bolster the abundances of naturally spawning fish, and following requirements for previous NMFS consultations (NMFS 2006a; 2012a), adults from the hatchery programs are also intended to spawn in natural areas used by natural-origin Chinook, coho, and pink salmon. However, the total abundances of natural- and hatchery-origin salmon are expected to remain well below surrogate carrying capacity levels estimated for the watershed (Ward et al., 2008; Pess et al. 2008) for the EFH salmon species over the term of this opinion. Predation by adult hatchery-origin salmon on juvenile natural Chinook salmon, coho, and pink salmon would be unsubstantial due to differences in emigration timings for hatchery fish released into the lower river and natural-origin salmon of individual sizes vulnerable to predation, and for the reasons described in section 2.4.1.1.1.9. For example, juveniles produced by naturally spawning hatchery-origin adults would be similar in size to the progeny of natural-origin parents, and so would not attempt to prey upon them.

Adult fish produced through the Chinook salmon, pink salmon and coho salmon hatchery programs may affect the genetic diversity of the natural-origin components of the Elwha River populations. As described in section 2.4, above, supportive breeding actions proposed through implementation of the hatchery programs for the species may adversely affect the diversity of the aggregate hatchery and natural-origin populations remaining in the Elwha River through within population diversity loss and hatchery-induced selection. These effects are not likely to be substantial over the time span for coverage of the programs through this opinion. Further, the programs considered in the opinion would operate only during the preservation and recolonization phases of fish restoration, when the benefits to preserving the species and restoring the abundance of the already depressed salmon populations in inhospitable lower river and estuary habitat as a result of dam removal outweigh hatchery-related risks to the genetic diversity of the populations. Of over-riding importance is preservation and restoration of the total abundance of the species during the dam removal period and for the period after removal as habitat in the lower river and estuary recovers. Diversity of the populations is expected to benefit over time as the naturally spawning component of each species recolonizes and adapts to newly accessible upper river habitat, as hatchery programs for the species are decreased in size and scope or phased out entirely, and in response to restoration of properly functioning habitat conditions in the lower river and estuary.

3.3. Essential Fish Habitat Conservation Recommendations

NMFS believes that the proposed actions, as described in WDFW 2012; LEKT 2012a; 2012b; 2012c; and LEKT and WDFW 2012, and the incidental take statement (section 2.8) include the best approaches for avoiding or adequately minimize risks of adverse effects on EFH for Chinook, coho, and pink salmon.

As described in section 2.4, the effects of water withdrawal for the hatchery facilities used to implement the proposed actions, including removal of water from the Elwha River, screening used at the withdrawal site, and facility structural design, were previously evaluated by NMFS in separate consultations and determined to be adequately protective of EFH (NMFS 2006a; 2010b; 2012a). Through that consultation, to avoid, mitigate, or offset impacts of the proposed action, NMFS included terms and conditions pertaining to surface water withdrawal structure design and operation. Those terms and conditions were determined as necessary measures to further minimize risks to EFH that may potentially be associated with water withdrawal methods and levels under the proposed action.

The biological opinion explicitly discusses the potential genetic, ecological and demographic effects on natural-origin fish populations and their ecosystems associated with hatchery salmon and steelhead production. The opinion also describes hatchery program implementation and monitoring actions appropriate for minimizing the potential adverse effects of hatchery-related hazards on salmon in the Elwha River Basin that may result from the proposed action (section 2.6). Although viewed as subordinate to the need to address demographic risks, the need to minimize genetic effects the may result from hatchery-origin fish spawning in natural-origin salmon production areas is addressed in the incidental take statement (section 2.8). The programs are conditioned to make on-station releases of juvenile hatchery-origin fish the primary focus of supportive breeding actions, with an emphasis on transporting and releasing adult rather than juvenile fish above the dam locations. Both of these measures will help minimize the level of hatchery intervention effects, including hatchery-induced selection risks, for the naturally spawning fish populations. The incidental take statement also includes measures requiring that the hatchery programs be operated to reduce the potential for interactions between juvenile hatchery and natural-origin fish in rearing and migration areas through timing and area of release limits designed to provide spatial and temporal separation. NMFS is not providing additional conservation recommendations to address these potential EFH effects; the action agencies shall ensure that the measures pertaining to EFH effects in the incidental take statement are carried out.

NMFS expects that full implementation of the pertinent requirements described in the incidental take statement would protect designated EFH for Pacific coast salmon by avoiding or minimizing the adverse effects described in section 3.2, above. Because of the nature of the potential effects, the proposed action would not substantially affect EFH and would not alter the areal extent and condition of designated EFH.

3.4. Statutory Response Requirement

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

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

3.5. Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are NOAA's National Marine Fisheries Service (NMFS), the National Park Service, the Bureau of Indian Affairs, and the U.S. Fish & Wildlife Service. Other interested users could include, but is not limited to, the Lower Elwha Klallam Tribe (LEKT); WDFW; the other Point No Point Treaty Tribes, and other Treaty Tribes within the U.S. v Washington Case Area; local city and county governments, the citizens of Clallam County, including the City of Port Angeles; visitors to Olympic National Park; recreational and commercial fisheries organizations; Federal and state agency scientists; and other non-governmental organizations and individuals with an interest in Elwha River fish and habitat restoration. Individual copies of this opinion were provided to the LEKT and WDFW. This opinion will be posted on the NMFS Northwest Region web site (*http://www.nwr.noaa.gov*). The format and naming adheres to conventional standards for style.

4.2. Integrity

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

4.3. Objectivity

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

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

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

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with Northwest Region ESA quality control and assurance processes.

5. References

5.1. Federal Register Notices

61 FR 4722. February 7, 1996. Interagency Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act

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Appendix Table 1. Summary of Hatchery Scientific Review Group (HSRG) reviews, core findings, and responsive revisions for HGMPs prepared by WDFW and the Lower Elwha Klallam Tribe for Chinook salmon, steelhead, coho salmon, and fall chum salmon programs in the Elwha River watershed.

Background – Formation of the Elwha Fish Restoration Plan" (Plan) began in 1993 (Agency and public review opportunities found in Table 1, including review by the NMFS Science Center (NWFSC 2003) and the NMFS Puget Sound Technical Recovery Team (PSTRT 2005)). The Plan was finalized as a NOAA Technical Memorandum in 2008 (Ward et al. 2008). There were three independent scientific reviews by the "Hatchery Scientific Review Group" (HSRG).

HSRG 2001. "Preliminary Review of the Elwha River Fish Restoration Plan (ver. 08/15/00) 2001".

Core Findings:

- Need to identify short-term and long-term goals for each species;
- Include a review of scientific literature to establish a scientific foundation for proposed options;
- Include benefit-risk assessments of the options with natural recolonization viewed as the standard to which other options are compared;
- describe a science-based strategy for success that views each option as a scientific experiment with monitoring and evaluation plans integrated with those options;

Plan Revision Response: The Plan was revised to address HSRG concerns. Revisions included:

- development of a monitoring and evaluation approach to gage the effects of hatchery production in meeting species preservation/restoration objectives and to track the status and productivity of naturally spawning fish.
- prioritization of on-station releases of hatchery juveniles over transport upstream.
- inclusion of further scientific rationale for the reliance on artificial propagation of fish.
- include production/outplanting of multiple life history stages as a spread-the-risk measure.

HSRG. 2002. Puget Sound Hatchery Reform Project. HSRG recommendations included in the Plan.

Core Findings:

- need to include contingencies for custody of the genetic resource under different environmental scenarios, including a schedule for disposition of returning adults as a function of run size.
- consider the out-planting of adults into the upper watershed as a part of the recovery strategy.
- revise hatchery production strategies to be more consistent with the conservation and re-colonization goals by: reducing or eliminating the transport of eggs and fry outside the watershed; mimic natural life history patterns using a combination of release strategies; incorporate natural-origin fish as broodstock; ensure stock security through diverse

rearing and release strategies and redundancy of facilities and systems; and developing an explicit schedule that takes into account both genetic and demographic risks as a function of spawner abundance, composition and population trends.

- additional consultation between the Elwha Recovery Team and the HSRG would likely be beneficial for development and refinement of the restoration and recovery plan.

Plan Revision Response: The draft Plan was revised to address HSRG concerns. Revisions included:

- development of schedules for application of various hatchery fish release type/location and natural escapement approaches, based on returning adult run return strength for each species.
- Incorporate upstream planting/release of adult fish as part of the restoration strategy.
- Implement changes in hatchery management and release strategies, including development of a plan to create a genetic reserve for the Elwha Chinook salmon population at Morse Creek, and release of different life stages of each species under the Plan to mimic natural life history patterns.

HSRG 2004. Comments on 2004 Revised Plan. Letter from Lars Mobrand (HSRG Chair).
Core Findings:

- pleased at the inclusion of contingency plans.
- supports the Plan's use of the multiple recovery strategies .
- The Plan could provide improved scientific rationale and a clear, organized and cohesive blueprint was needed for a restoration project of this importance and high profile:
    - Establish well-defined goals for each stock to improve the ability to evaluate the benefits and risks of a hatchery program;
    - Make the plan more defensible by clearly articulating scientific rationale for a hatchery;
    - program (including natural fish abundance benchmarks for decreasing hatchery programs) to provide a science-based foundation a range of scientific tools and strategies for achieving goals and decision-making;

Plan Revision Response: The draft Plan was further revised to include:

- plan goals: the Elwha group felt that there is great uncertainty about abundance levels that the watershed historically supported, what it might support after the dams are removed, and expectations for abundance performance over time. Rather than develop short and long term triggers for guiding hatchery strategies as suggested by the HSRG, the Plan instead relies on a planned 10 year term, with adult escapement abundance trigger levels that are used to direct decisions regarding hatchery fish release-type production levels and the upstream release/passage of returning adult fish.
- The Plan identifies "recovery expectations" and VSP 'interim restoration targets" for each species (Table 25 of the Plan), defined in terms of expected total production of anadromous adult salmon, based on assumed habitat productivity and fishery harvest rate levels.

- the Plan assumes that "true" productivity, escapement, and harvest goals will be developed at a later date, when specific information is available for the Elwha Basin. Initial goals for total production and rates of recovery will be updated as the recolonization process proceeds and information is gathered regarding the inherent productivity of the Elwha watershed. Monitoring activities will be expected to provide important feedback on initial modeling efforts.
- "Monitoring and Adaptive Management" section was included to evaluate the success or failure of management actions.
- Inclusion of a suite of testable hypotheses for each of the monitoring objectives (recolonization; genetic diversity and population integrity; fish health response; and ecosystem recovery) specifying desired or expected outcomes for recovery.

Literature Citations

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Appendix Table 2. Synopsis of Federal/State Review Processes and Opportunities for Public Review and Comment - Elwha Fish Restoration Plan and Component Actions.

Year	Action and Review Process	Lead Agency	Actions Reviewed	Public Review & Comment
1993	"The Elwha Report" – public review draft	NPS	Early draft of the "Fish Plan" including hatchery supplementation actions, part of the "definite plan" for dam removal under the Elwha River Ecosystem and Fisheries Restoration Act (Elwha Act).	Yes (included public meetings)
1994	Draft Programmatic Environmental Impact Statement for Elwha River Ecosystem Restoration	NPS	Fish preservation and restoration actions using hatcheries included with other actions proposed under preferred alternative to restore river to a natural condition.	Yes (included public meetings)
1995	Final Programmatic Environmental Impact Statement for Elwha River Ecosystem Restoration and ROD	NPS	Fish preservation and restoration actions using hatcheries included with other actions under final preferred alternative to restore river to a natural condition.	Yes
1996	Draft and Final Implementation Environmental Impact Statement for Elwha River Ecosystem Restoration	NPS	Fish preservation and restoration plan further developed and included in draft and final Implementation EISs for public review and comment.	Yes (included public meetings)
2004	Draft Supplement to Final Programmatic Environmental Impact Statement for Elwha River Ecosystem Restoration	NPS	Updated information/data for fisheries restoration plans were included in the Supplement addressing project changes (water quality mitigation)	Yes (included public meetings)
2005, 2007	Shared Strategy Plan – Development, review, and approval process – Volume II – Elwha Watershed component	NMFS	Draft (2005) Elwha Fish Restoration Plan, in its entirety, included in Elwha watershed chapter for grass roots organization development, public review and SSP submittal (2005), and NMFS approval (2007)	Yes
2005	WDFW HGMP Public Review and Comment Process – (60 day notice of intent to sue settlement)	WDFW	All draft Puget Sound region hatchery plans, including HGMP for Elwha Channel Chinook salmon program, provided for public review and comment as part of settlement with Washington Trout (now Wild Fish Conservancy)	Yes
2011	Hatchery Action Advisory Group	WDFW	NGO review of Puget Sound co-manager hatchery management plans, including all HGMPs proposed under the Elwha Fish Restoration Plan	Yes – on-going
2012	Puget Sound Hatcheries EIS	NMFS	Effects of all Puget Sound anadromous salmonid hatcheries on the environment, including Elwha plans (DEIS – winter, 2012)	Yes – planned
2012	4(d) Limit 6 Evaluation Pending Determination for Puget Sound anadromous salmonid hatchery programs	NMFS	NMFS pending determination regarding hatchery-related effects on listed Puget Sound Chinook salmon and Puget Sound steelhead, including Elwha plans	Yes - planned

Additional scientific reviews of the Elwha Fish Restoration Plan (EFRP) and proposed hatchery actions included in the Plan:

- HSRG 2001. "Preliminary Review of the EFRP (ver. 08/15/00)2001". HSRG 2001 review of the 2000 EFRP version, as requested by the "Elwha Fisheries Technical Group".

- HSRG 2002. "Puget Sound and Coastal Washington Hatchery Reform Project – Eastern Strait". Comments on co-manager Elwha salmon and steelhead programs included in revised form in subsequent EFRP drafts.
- NWFSC 2003 – Center review and comment on October, 2003 version of the EFRP (George Pess, with input from Gary Winans and Mike Ford).
- HSRG 2004. Response letter to the "Elwha Recovery Team" (from Lars Mobrand (Chair) to c/o Larry Ward) providing HSRG review comments on the revised EFRP.
- Puget Sound Technical Recovery Team 2005- Full TRT review of the 2005 draft EFRP as part of a general overall evaluation of the restoration strategy in the context of PS Chinook salmon ESU recovery planning.
- NMFS NWFSC 2006 – NWFSC Sept-October 2006 peer review of the March 17, 2006 draft EFRP (Mary Ruckelshaus, Jim Myers. Phil Roni) prior to submittal of plan for publication as a NWFSC technical memo.
- NOAA NWFSC 2008 – NOAA Technical Memorandum NMFS-NWFSC-90 "Elwha Fish Restoration Plan" (Ward et. al 2008) – final plan collaboratively completed by a multi-agency resource management and scientific group with specific expertise on the Elwha: NPS, USFWS, NMFS NWFSC, NMFS NWR, WDFW, and Lower Elwha Klallam Tribe.

Appendix Table 3. Species of fishes with designated EFH occurring in Strait of Juan de Fuca.

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