Draft Environmental Assessment

Determination that the Hatchery and Genetic Management Plans for Sandy River Programs Submitted by the Oregon Department of Fish and Wildlife Satisfy the Endangered Species Act Section 4 (d) Rule under Limit 5

National Marine Fisheries Service
West Coast Region

February 2015

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Cover Sheet
February 2015 Public Review Draft

Title of Environmental Review:	Environmental Assessment to Analyze Impacts of a NOAA's National Marine Fisheries Service Determination that the Hatchery and Genetic Management Plans Submitted by the Oregon Department of Fish and Wildlife Satisfy the Endangered Species Act Section 4(d) Rule under Limit 5
Evolutionarily Significant Units:	Lower Columbia River Chinook salmon Lower Columbia River Coho salmon Columbia River Chum salmon Lower Columbia River Steelhead Pacific Eulachon
Responsible Agency and Official:	Barry Thom Deputy Regional Administrator West Coast Region National Marine Fisheries Service 7600 Sand Point Way N.E., Building 1 Seattle, WA 98115
Contacts:	Richard Turner Sustainable Fisheries Division West Coast Region National Marine Fisheries Service 1201 NE Lloyd Blvd, Suite 1100 Portland, OR 97232
Legal Mandate:	Endangered Species Act (ESA) of 1973, as amended and implemented – 50 CFR Part 223
Location of Proposed Activities:	Sandy River, Oregon
Activity Considered:	Endangered Species Act determination regarding four Hatchery Genetic and Management Plans through part of the range of the ESA-listed Evolutionarily Significant Units and Distinct Population Segment pursuant to Limit 5 of the ESA 4(d) Rule

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1. Purpose of and Need for the Proposed Action

1.1. Background

NOAA's National Marine Fisheries Service (NMFS) is the lead agency responsible for administering the Endangered Species Act (ESA) as it relates to listed salmon and steelhead. Actions that may affect listed species are reviewed by NMFS under section 7 or section 10 of the ESA or under section 4(d), which can be used to limit the application of take prohibitions described in section 9. NMFS issued a final rule pursuant to ESA section 4(d) (4(d) Rule), adopting regulations necessary and advisable to conserve threatened species (50 CFR 223.203). The 4(d) Rule applies the take prohibitions in section 9(a)(1) of the ESA to salmon and steelhead listed as threatened, and also sets forth specific circumstances when the prohibitions will not apply, known as 4(d) limits. With regard to hatchery programs described in Hatchery and Genetic Management Plans (HGMPs), NMFS declared under limit 5 of the 4(d) Rule that section 9 take prohibitions would not apply to activities carried out under those HGMPs that have been approved by NMFS and that are implemented in accordance with a letter of concurrence from NMFS.

In July 2011, scoping was completed on four hatchery programs and their associated HGMPs. A concurrence memorandum and Scoping Agenda for these programs was signed August 15, 2011. Subsequently a concurrence memorandum for modifications to the scoping documents was signed on June 6, 2012. An National Environmental Policy Act (NEPA) environmental assessment (EA) and Finding of No Significant Impact (FONSI) for these programs were completed and signed September 28, 2012 (NMFS 2012c). At the same time, an ESA Section 7 biological opinion with an incidental take statement (2012 opinion) was completed for the issuance of a concurrence letter approving the four HGMPs under limit 5 of the ESA 4(d) Rule (NMFS 2012b).

On November 4, 2013, NMFS received four updated HGMPs from the Oregon Department of Fish and Wildlife (ODFW), describing hatchery programs that release salmon and steelhead into the Sandy River affecting Lower Columbia River (LCR) Chinook salmon, LCR coho salmon, Columbia River (CR) chum salmon, and LCR steelhead in 2014 and beyond (ODFW 2013e; 2013d; 2013c; 2013b). These new HGMPs described changes to the hatchery programs that were evaluated in the September 2012 EA and the 2012 opinion, and the changes were substantial enough to trigger a new 4(d) approval process. For the purpose of this NEPA analysis, the four submitted plans will be collectively referred to as the 2013 HGMPs that describe the hatchery programs.

In the ESA review of hatchery programs, NMFS must consider whether these HGMPs satisfactorily address the criteria contained in the ESA under limit 5 of the 4(d) Rule. If NMFS determines that the HGMPs submitted by ODFW "...are not likely to appreciably reduce the likelihood of survival and recovery..." and otherwise satisfy criteria of the 4(d) Rule, then NMFS can approve the HGMPs. NMFS' approval of the HGMPs constitutes the Federal action that is subject to analysis as required by NEPA.

NMFS seeks to consider, through NEPA analysis, how its pending ESA approval action may affect the natural and physical environment and the relationship of people with that environment.

NMFS is also required to review compliance of ESA actions with other applicable laws and regulations. The NEPA analysis provides an opportunity to consider, for example, how the action may affect conservation of non-listed species and socioeconomic objectives that seek to balance conservation with wise use of affected resources and other legal and policy mandates.

1.2. Description of the Proposed Action

The Federal action evaluated here is the proposed approval by the Secretary (through the Northwest Regional Administrator for NMFS) of ODFW's 2013 Sandy River HGMPs including a determination that activities described by the HGMPs would not appreciably reduce the likelihood of survival and recovery of the ESA-listed LCR Chinook Salmon and LCR Coho Salmon Evolutionarily Significant Units (ESU), and the LCR Steelhead Distinct Population Segment (DPS)[1]. The Proposed Action would result in the implementation of hatchery programs as described in the 2013 HGMPs.

Implementation of the programs would include use of funds distributed by NMFS to ODFW pursuant to the Mitchell Act (Subsection 1.6, Relationship to Other Plans and Policies). These funds are distributed through the Federal grant process, and a NEPA review is conducted at the time the grant requests are received; therefore, the analysis of HGMP implementation does not include the grant actions. NMFS has also analyzed the distribution of Mitchell Act funds programmatically across the Columbia River Basin in an Environmental Impact Statement (EIS) (NMFS 2014). This EIS includes analysis of the Sandy River hatchery programs, and the final EIS is hereby incorporated by reference (NMFS 2014).

Alternatives considered in this EA are:

(1) No-action Alternative – continue to operate the four hatchery programs as described in the 2012 opinion;

(2) No-hatchery Alternative – do not approve the four HGMPs under limit 5 of the 4(d) Rule, resulting in the termination of the hatchery programs;

(3) Reduced Production Alternative – hatchery programs would release juveniles at levels to achieve a proportion of hatchery fish in the spawning population (pHOS) that is less than 5 percent; and

(4) Proposed Action – approve the 2013 HGMPs under limit 5 of the 4(d) Rule.

No other alternatives that would meet the purpose and need were identified that were appreciably different from the alternatives analyzed in detail below (Section 2.0, Alternatives Including the Proposed Action).

[1] An 'evolutionarily significant unit' (ESU) of Pacific salmon (Waples 1991) and a 'distinct population segment' (DPS) of steelhead (71 FR 834, January 5, 2006) are considered to be 'species,' as defined in Section 3 of the ESA. Unless otherwise stated, this document uses the term 'species' to refer to both ESUs and DPSs.

1.3. Purpose of and Need for the Action

The purpose and need for the Proposed Action is to ensure that on-going and proposed hatchery programs for the production of spring Chinook salmon, coho salmon, winter steelhead, and summer steelhead as described in the four 2013 HGMPs comply with the requirements of the ESA. The hatchery programs are designed to meet mitigation responsibilities, related to fisheries impacts from development in the Sandy River (i.e., operation of the Bull Run Water Supply (NMFS 2008b)) and Columbia River Basins (via the Mitchell Act(ODFW 2013b)), by providing hatchery fish to support fishing opportunities while minimizing potential risks to natural-origin spring Chinook salmon, coho salmon, and winter steelhead populations, consistent with Oregon's Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (hereafter Oregon Recovery Plan)(ODFW 2010a) and NMFS' LCR Salmon and Steelhead Recovery Plan (hereafter NMFS Recovery Plan)(NMFS 2013c). ODFW procures funds distributed by NMFS under the Mitchell Act to support its hatchery programs, with the identical purpose of meeting mitigation responsibilities.

The purpose of and need for the Proposed Action from the applicant's perspective is for the continuation of on-going and proposed hatchery production described in the four 2013 HGMPs that would provide fishing opportunities for the citizens of the Columbia River Basin while conserving natural-origin populations and, thereby, meeting requirements for future Mitchell Act funding of specific actions related to these HGMPs. In fulfilling the purpose and need, the Proposed Action would provide hatchery fish production for meeting mitigation responsibilities.

1.4. Analysis Area

The Sandy River in Oregon enters the Columbia River at river mile (RM) 120.5. Originating in the Reid, Sandy, and Zigzag Glaciers on the west slope of Mt. Hood (elevation 11,235 feet) and flowing in a northwesterly direction for 55 miles, the Sandy River and its tributaries drain an area of 508 square miles (Figure 1). While the action area is large due to the amount of habitat for the species being analyzed, impacts from the operation of the hatchery programs tend to be localized to areas immediately adjoining the hatchery facility on Cedar Creek, the acclimation site on the lower Bull Run River, and the weir locations on the Bull Run, Salmon, and Zigzag Rivers (Figure 1).

NMFS considered whether the mainstem Columbia River, the estuary and the ocean should be included in the analysis area, but the effects analysis was unable to detect or measure effects of the Proposed Action beyond the Sandy River Basin. Available knowledge and research abilities are insufficient to discern the role and contribution of the Proposed Action to density dependent interactions affecting salmon and steelhead growth and survival in the mainstem Columbia River, the Columbia River estuary, and in the Pacific Ocean. NMFS' general conclusion is that the influence of density dependent interactions on growth and survival is likely small compared with the effects of large scale and regional environmental conditions. While there is evidence that hatchery production, on a scale many times larger than the Proposed Action, can impact salmon survival at sea, the degree of impact or level of influence is not yet understood or predictable, nor is there any evidence that programs of this size have effects in the ocean. Thus,

impacts of the programs on the human environment outside the Sandy River Basin are not expected.

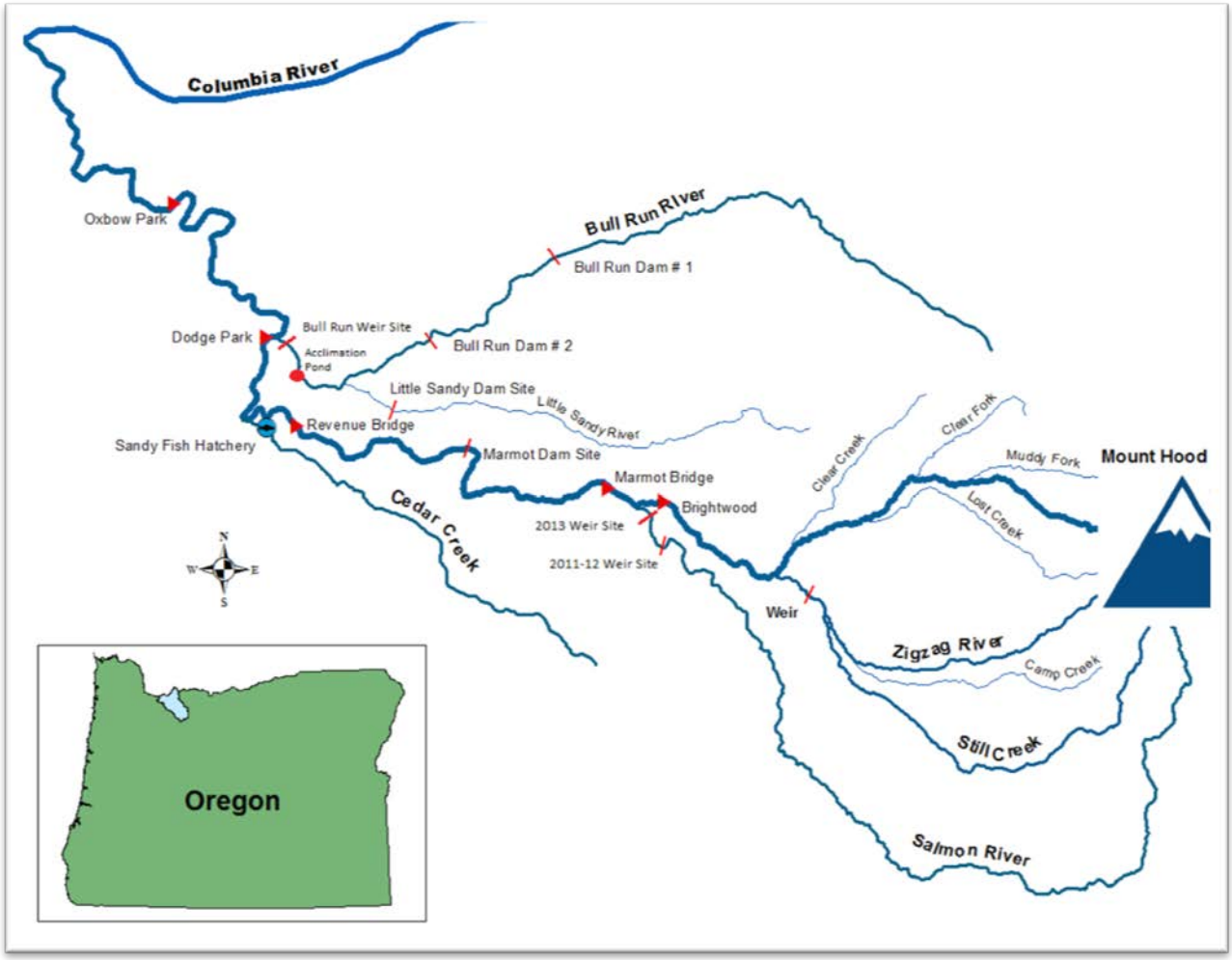

Figure 1. Sandy River Basin, Sandy Hatchery facilities and weir sites considered in this analysis. Note that the Little Sandy Dam and the Marmot Dam and fish facilities were removed in 2007.

As described below under the Proposed Action, limitations on the quantity and quality of water in Cedar Creek used by the Sandy Hatchery means that not all of the hatchery production can occur at the Sandy Hatchery. Hatchery salmon and steelhead produced for the proposed hatchery programs would be reared at a number of facilities outside the immediate action area. These include the Bonneville Hatchery, Oxbow Hatchery, and Cascade Hatchery in Multnomah County, the Clackamas Hatchery in Clackamas County, the South Santiam Hatchery in Linn County, and the Oak Springs Hatchery in Wasco County. All of these hatcheries rear salmon and steelhead for other hatchery programs and the production for the proposed Sandy Hatchery programs is only a small part of the overall production at these hatcheries. All of the hatchery salmon and steelhead reared at these hatcheries for the Sandy River programs would be released at the Sandy Hatchery or at the Bull Run River acclimation pond and not outside the Sandy River

Basin. Impacts on the natural environment from the operation of these hatcheries would continue to occur and would not be expected to change due to the inclusion or exclusion of the proposed Sandy Hatchery programs.

1.5. Scope

The scope of the action considered here includes the rearing and release of hatchery salmon and steelhead in the Sandy River. The review addresses potential effects in the entire analysis area, although adult collection, rearing, and release activities would occur in localized areas only. The HGMPs would be in effect after the associated ESA 4(d) determinations are signed, and would remain in effect until ODFW replaces or retracts them, or until NMFS determines that that the plans are no longer effective. There would be periodic reviews of these HGMPs by NMFS every 5 years, and the plans would be modified as warranted by NMFS, as would be specified in the approval of the plans pursuant to Limit 5 of the 4(d) Rule.

There are four ESA-listed anadromous salmonid species under NMFS jurisdiction that are present in the Sandy River Basin (Table 1). Note that Columbia River chum salmon were found historically in the Sandy River Basin, but are currently extirpated (ODFW 2010a). In addition to the three salmonid species, NMFS has also listed as threatened under the ESA the southern distinct population of Pacific eulachon (*Thaleichthys pacificus*), which is present in the Sandy River Basin (Table 1).

Table 1. Federal Register notices (publication date and citation) for final listing status determinations, designation of critical habitat, and protective regulations for listed species under NMFS jurisdiction considered in this consultation.

	Listing Status Determination	**Critical Habitat Designation**	**Protective Regulations**
Chinook salmon (*Oncorhynchus tshawytscha*)			
Lower Columbia River Chinook Salmon	June 28, 2005; 70 FR 37160	September 2, 2005; 70 FR 52630	June 28, 2005; 70 FR 37160
Coho Salmon (*Oncorhynchus kisutch*)			
Lower Columbia River Coho Salmon	June 28, 2005; 70 FR 37160	[not yet designated]	June 28, 2005; 70 FR 37160
Steelhead (*Oncorhynchus mykiss*)			
Lower Columbia River Steelhead	January 5, 2006; 71 FR 834	September 2, 2005; 70 FR 52630	June 28, 2005; 70 FR 37160
Chum Salmon (*Oncorhynchus keta*)			
Columbia River Chum Salmon	June 28, 2005; 70 FR 37160	September 2, 2005; 70 FR 52630	June 28, 2005; 70 FR 37160
Pacific Eulachon *(Thaleichthys pacificus)*			
Southern Distinct Population Segment	March 18, 2010; 74 FR 13012	October 20, 2011; 76 FR 65324	October 20, 2011 76 FR 65324

1.6. Relationship to Other Plans and Policies

This EA was prepared pursuant to regulations implementing NEPA (42 USC 4321), in compliance with Federal regulations for preparing an EA (40 CFR 1502), and consistent with recovery plans being developed pursuant to section 4 of the ESA by NMFS in conjunction with interested stakeholder groups. The Proposed Action analyzed in this EA relates to other plans and policies regarding the management and restoration of anadromous fish resources in the Pacific Northwest and ESA recovery planning.

City of Portland Habitat Conservation Plan

The City of Portland is currently mitigating for the fisheries and habitat impacts of the Bull Run water supply under a habitat conservation plan (HCP). The City of Portland completed, and NMFS approved, the Bull Run Water Supply Conservation Plan (HCP) in 2008 (NMFS 2008b). The primary focus of the HCP is protection for natural-origin ESA-listed anadromous fish under the jurisdiction of NMFS. By following the HCP commitments, the City of Portland is achieving compliance with the ESA and Clean Water Act for all Bull Run water supply operational impacts. In addition, in 1979, the City of Portland received a hydropower license from the Federal Energy Regulatory Commission (FERC) to install electric power production facilities at the Bull Run dams. Under the terms of that license and an agreement with ODFW, the City of Portland each year provides ODFW money to produce hatchery fish for release into the Sandy River Basin. In return, ODFW agreed to seek no additional actions by the City of Portland based on the construction and operation of the hydropower dams as long as the City operated in compliance with the FERC license.

The City of Portland's hydropower license term expires in 2029, while the HCP's term expires in 2059. Under the terms of the HCP Implementation Agreement signed by NMFS and the City of Portland, if the City of Portland seeks to renew its hydropower license, it must incorporate the HCP into its relicense application. The purpose of this is to assure, absent substantially change circumstances, that the HCP terms will become the fish and wildlife protection conditions for any new license.

There are 49 conservation measures in the HCP (NMFS 2008b), and they are being implemented in the Bull Run Basin and elsewhere in the greater Sandy River Basin. The HCP provides funding for habitat improvement projects and monitoring and evaluation efforts, all targeted towards improving natural-origin fish populations. The City of Portland is also providing much of the funding to improve the Sandy Hatchery intake structure.

Endangered Species Act Recovery Plans

Recovery plans are in place or being developed for most parts of the Columbia River system in which anadromous fish occur (for example, see (ODFW 2010c; 2010a; NMFS 2013c). Typically, development and on-going implementation of these plans includes participation by multiple Federal, tribal, state, and local agencies and stakeholder groups. These recovery plans contain (1) measurable goals for delisting, (2) a comprehensive list of the actions necessary to achieve delisting goals, and (3) an estimate of the cost and time required to carry out those actions.

After listing 27 Pacific salmon ESUs as threatened or endangered under the ESA, NMFS initiated a coastwide process to develop recovery plans for these species. An important part of this process was the creation of geographically based Technical Recovery Teams (TRTs). The TRTs are multi-disciplinary science teams chaired by the NMFS' Northwest Fisheries Science Center or the NMFS' Southwest Fisheries Science Center staff. They were tasked with providing science support to recovery planners by developing biologically based viability criteria, analyzing alternative recovery strategies, and providing scientific review of draft plans.

With the imminent publication of recovery plans for most ESA-listed salmon and steelhead in the Pacific Northwest, the Pacific Northwest TRTs have completed their initial tasks of developing viability criteria and providing science support for recovery plan development. Most of the original TRTs have, therefore, been phased out as the TRTs completed their final tasks in late 2007 and early 2008.

A draft plan for the LCR salmon and steelhead populations in Oregon (i.e., Recovery Plan; (ODFW 2010a)) has been completed and has been combined, by NMFS, with the Lower Columbia Fish Recovery Board's updated recovery plan for Washington populations (LCFRB 2010), into the final Lower Columbia River ESU/DPS-wide recovery plan (NMFS 2013c). All factors that have been identified as leading to the decline of ESA-listed salmon and steelhead are being addressed in the Recovery Plan. For ESA-listed Chinook, coho, and chum salmon and steelhead in the Sandy River Basin, these factors include hydroelectric operations, harvest, habitat use, and artificial propagation.

As discussed below (Section 3, Affected Environment), the 2013 HGMPs describe the salmon and steelhead that would be affected in a manner consistent with the population descriptions given by the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT) (Myers et al. 2006). The Recovery Plan (ODFW 2010a) also included an assessment of the status of the Sandy River populations and built on the assessment completed by McElhany et al. (2007). These evaluations assessed the status of populations with regard to the Viable Salmonid Populations (VSP) parameters of abundance and productivity, spatial structure, and diversity (McElhany et al. 2000).

The decline in Pacific eulachon abundance in the Lower Columbia River from 1993 to 2000 led to the States of Oregon and Washington to develop the Joint State Eulachon Management Plan that was designed to provide research and management guidance primarily for Columbia River recreational and commercial fisheries targeting eulachon (WDFW and ODFW 2001).

Comprehensive Analysis

In 2008, NMFS concluded multiple ESA consultations for several Federal actions that occur simultaneously affecting the same listed species of Columbia River salmon and steelhead (NMFS 2008h; 2008f). The Federal Columbia River Power System (FCRPS) Action Agencies, with the U.S. Bureau of Reclamation for its Upper Snake projects, based their two biological assessments for their actions on a common comprehensive analysis entitled Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions (Corps et al. 2007). NMFS later prepared its own Supplemental

Comprehensive Analysis (SCA) to capture the best available data and analysis contemporaneous with its issuance of its biological opinions in 2008 (NMFS 2008h). NMFS' SCA builds on the FCRPS Action Agencies' Comprehensive Analysis, incorporating by reference the information relevant to NMFS' analysis on the FCRPS; that analysis includes information relevant to the consideration of fishery harvest in the Columbia and Snake Basins (NMFS 2008h).

Mitchell Act Funding

The Mitchell Act (16 United States Code [USC] 755-757: 52 Stat. 345) was enacted in 1938 for the conservation of anadromous (salmon and steelhead) fishery resources in the Columbia River Basin (defined as all tributaries of the Columbia River in the United States and the Snake River Basin). It authorized the establishment, operation, and maintenance of one or more hatcheries in the states of Oregon, Washington, and Idaho; scientific investigations to facilitate the conservation of the fishery resource; and "all other activities necessary for the conservation of fish in the Columbia River Basin in accordance with law."

Since 1946, Congress has continued to appropriate Mitchell Act funds on an annual basis. These funds have been used to support research, improve fish passage, screen water diversions, and build and operate over 20 salmon and steelhead hatchery facilities. Each year, Congress allocates a specific portion of the money appropriated for the Mitchell Act to hatchery operations. For each of the past 10 years, hatchery program funding has been between $11 and 16 million dollars. NMFS currently distributes these appropriations to managers of 20 existing Columbia River hatchery facilities to support an annual production of more than 71 million fish in 62 hatchery programs. Mitchell Act funds for fiscal year 2013 were provided to ODFW for monitoring and evaluation activities in the Sandy River Basin, and hatchery production at other facilities (as described below). The operation of the Sandy Hatchery is funded by ODFW through license sales.

NMFS completed a Final Environmental Impact Statement (FEIS) that will guide NMFS in the annual funding of Mitchell Act hatchery programs in the Columbia River Basin (NMFS 2014b). The final EIS has been incorporated by reference by this EA. The FEIS not only evaluates Mitchell Act-funded hatchery programs, but all the hatchery programs within the Columbia River Basin, including the Sandy River hatchery programs. The FEIS evaluates likely effects of hatchery production on a broad species and multi-species scale (i.e., ESUs and DPSs) in the Columbia River Basin), while this EA specifically evaluates effects of the proposed Sandy River programs at a site-specific level of detail.

The draft EIS analyzing Mitchell Act funding included five alternatives (one no-action and four action alternatives) in the FEIS, NMFS formulated and evaluated a sixth alternative, the Preferred Alternative. The FEIS also provides an updated analysis of the original five alternatives evaluated in the draft EIS. FEIS Alternative 4 is most similar to the Proposed Action Alternative in this EA (EA Alternative 4). Specifically, FEIS Alternative 4 assumes that the spring Chinook salmon program would be integrated, and the coho salmon and summer steelhead programs would be operated the same as under the EA Proposed Action Alternative except that the number of smolts produced is less for Proposed Action Alternative in this EA than that what was evaluated in FEIS Alternative 4 (500,000 versus 700,000 coho salmon smolts; 75,000 versus 160,000 summer steelhead smolts).

Under FEIS Alternative 4, the winter steelhead program would be operated as a segregated program similar to the No-action Alternative in this EA. Alternative 1 in the FEIS did evaluate an integrated winter steelhead program in the Sandy River Basin that is consistent with the Proposed Action Alternative in this EA.

The FEIS Preferred Alternative differs from the EA Proposed Action because the Preferred Alternative in the FEIS incorporated the Sandy River hatchery programs approved in the 2012 NMFS biological opinion (NMFS 2012b). The Proposed Action Alternative in this EA describes the hatchery programs as they were proposed in HGMPs submitted in 2013.

2. ALTERNATIVES INCLUDING THE PROPOSED ACTION

Alternatives considered in this EA are:

(1) No-action Alternative – continue to operate the four hatchery programs as described in the 2012 opinion;

(2) No-hatchery Alternative – do not approve the four HGMPs under limit 5 of the 4(d) Rule, with the result that the hatchery programs would be terminated;

(3) Reduced Production Alternative – hatchery programs would release juveniles at levels to achieve a proportion of hatchery fish in the spawning population (pHOS) that is less than 5 percent; and

(4) Proposed Action – approve the HGMPs under limit 5 of the 4(d) Rule.

2.1. Alternative 1 (No-action) – Continue to Operate the Four Hatchery Programs as Described and Approved in the 2012 Biological Opinion

Under this alternative, the four hatchery programs would be operated as approved under limit 5 of the 4(d) Rule in the Concurrence Letter (NMFS 2012d) and described in the September 28, 2012 Biological Opinion and Incidental Take Statement (NMFS 2012b). The hatchery programs would continue to rear juveniles at all of the facilities described in the HGMPs, and release up to 300,000 spring Chinook salmon smolts, 500,000 coho salmon smolts, 160,000 winter steelhead smolts, and 75,000 South Santiam Hatchery summer steelhead smolts (Table 2). These hatchery programs have applied Best Management Practices (BMPs) as described in the Biological Opinion and Incidental Take Statement (NMFS 2012b). BMPs are a set of hatchery protocols designed with the goal of producing a smolt of sufficient quality to meet the objectives of the hatchery program and to minimize effects on natural-origin populations (IHOT 1995; HSRG 2004; Mobrand et al. 2005; Kostow 2009; NMFS 2010a; Kostow 2012). Each of the four hatchery programs is described below, providing details regarding management, hatchery operations, broodstock collection, rearing, and release.

Alternative 6 (Preferred Alternative) in the Mitchell Act FEIS is consistent with the four Sandy River hatchery programs that are included under this No-action Alternative. However, the anticipated coho salmon and summer steelhead releases under this No-action Alternative would

be lower than what was evaluated in the FEIS (500,000 versus 700,000 coho salmon smolts; 75,000 versus 160,000 summer steelhead smolts) (NMFS 2014b).

Table 2. Sandy River Hatchery releases under the four alternatives evaluated in this EA.

Hatchery Program Releases	No-action Alternative	No-hatchery Alternative	Reduced Production Alternative	Proposed Action Alternative
Spring Chinook Salmon	300,000	0	90,900	132,000
Coho Salmon	500,000	0	222,000	300,000
Winter Steelhead	160,000	0	125,000	160,000
Summer Steelhead	75,000	0	75,000	75,000

Note that under the Proposed Action Spring Chinook salmon releases could increase to 300,000 as long as pHOS goals are being achieved.

Sandy Hatchery is the primary location that would be used for the No-action Alternative. The Sandy Hatchery is located at river mile (RM) 0.75 on Cedar Creek, a tributary to the Sandy River (Figure 1). The hatchery uses water from Cedar Creek, totaling up to 12,577 gallons per minute (gpm) under Oregon water permit number 23300 (issued December 3, 1954). Water is supplied to the hatchery by gravity flow with a high flow of 8,000 gpm in March and a low flow of 1,800 gpm in July/August. The hatchery intake on Cedar Creek is 100 percent screened throughout the year; and the screens are considered compliant with current NMFS fish screening criteria (NMFS 2008a). Return water from the Sandy Hatchery is authorized under National Pollutant Discharge Evacuation Permit (NPDES) 300-J General Permit 10598.

To meet permit requirements, hatchery effluent would be passed through a pollution abatement pond to remove sediment (e.g., total suspended solids and settleable solids). There is an adult weir at the Sandy Hatchery that is operated to prevent hatchery adults from spawning in upper Cedar Creek. Natural-origin adult winter steelhead and coho salmon collected at the hatchery are passed above the weir to spawn naturally. Adult natural-origin spring Chinook salmon that stray into Cedar Creek and are collected at the hatchery are returned to the Sandy River to spawn naturally. Cedar Creek does not contain spring Chinook salmon spawning habitat.

2.1.1. Sandy River Spring Chinook Salmon Program

The Sandy River Spring Chinook Salmon program, as described in the HGMP (ODFW 2011a), is an on-going program that was approved under the Concurrence Letter (NMFS 2012d) and described in the September 28, 2012, Biological Opinion and Incidental Take Statement (NMFS 2012b). Under the No-action Alternative this program would continue to release 300,000 in-basin-origin hatchery spring Chinook salmon smolts (designated as Oregon stock 11) to augment the Sandy River, Lower Columbia, and ocean spring Chinook salmon fisheries. These releases are to mitigate for the loss of spring Chinook salmon catch in recreational and commercial fisheries due to habitat degradation and passage impairment resulting from construction and operation of dams by Portland General Electric (Marmot Dam, removed in 2007 and no longer requiring mitigation) and the City of Portland (dams on the Bull Run River, a tributary to the lower Sandy River). Mitchell Act funds for fiscal year 2013 were provided to ODFW for monitoring and evaluation activities in the Sandy River Basin, and hatchery production at other

facilities (as described below). The operation of the Sandy Hatchery is funded by ODFW through license sales and by the City of Portland.

There are no numeric harvest goals for ocean, Columbia River, and Sandy River fisheries; however, a minimum of 200 adults is needed to meet broodstock objectives (ODFW 2011a). In-basin harvest of Sandy River hatchery spring Chinook salmon has ranged from 324 to 4,436 adults during the period from 1995 to 2009 (Table 3.3.1a in (ODFW 2011a)). The harvest of Sandy River spring Chinook salmon in ocean, Columbia River, and Sandy River fisheries has averaged 3,165 adults for brood years 1994 to 2004. Total harvest has declined for the most recent brood years due to a reduction in the total number of smolts released and changes in fisheries management (ODFW 2011a).

The harvest of the Sandy River hatchery-origin spring Chinook salmon is managed to comply with the Fisheries Management and Evaluation Plan (FMEP) for Lower Columbia River Chinook salmon, which explains the management implications of holding a recreational fishery where hooking mortality of listed fish may occur (see the evaluation of the FMEP in (NMFS 2003b) and other fisheries in (NMFS 2008c; 2008g). Since 2003, refinements in fisheries management within the Sandy River Basin as assessed by NMFS (NMFS 2007c) have occurred. These refinements are largely due to the removal of Marmot Dam; Section 4, Environmental Consequences, below, updates and considers the effects of those adjustments. Current fishing regulations in the area of the Lower Columbia River Chinook Salmon ESU require that all unmarked adult spring Chinook salmon be released back to the water unharmed. Only adult spring Chinook salmon marked with an adipose fin-clip may be retained in recreational fisheries. Mainstem Columbia River commercial fisheries also require the release of unmarked adult spring Chinook salmon, and ocean fisheries are investigating techniques to facilitate the safe release of unmarked fish.

The effects of the No-action Alternative on the fisheries in the Sandy River are included in this analysis. The effects of the No-action Alternative on fisheries outside the Sandy River Basin (Ocean and Columbia River mainstem fisheries) would not be discernible because Sandy River hatchery production accounts for only a small percentage of the total spring Chinook salmon available to the ocean and mainstem fisheries (ODFW and WDFW 2011; NMFS 2013c), and thus will not be considered further in this analysis.

The Sandy River spring Chinook salmon hatchery program continues to evolve to keep pace with best management practices for operating a hatchery program and protecting ESA-listed salmon and steelhead. Starting with broodstock management, beginning in 2002, the program switched broodstock to reduce the threat of genetic introgression on the natural-origin spring Chinook salmon population from the release of the non-endemic Clackamas spring Chinook salmon (Upper Willamette stock spring Chinook salmon). For broodyears 2002 to 2007, only unmarked spring Chinook salmon (natural-origin Sandy River spring Chinook salmon) collected at Marmot Dam were used for broodstock for the new program. In 2007, fewer than 50 six year-old Clackamas Hatchery adults from the 2003 release (2001 broodyear) returned to the basin. These were the last of the Clackamas Hatchery fish to return to the Sandy River Basin and these fish were removed at Marmot Dam before they could spawn naturally.

Once hatchery and natural-origin spring Chinook salmon in the Sandy River Basin shared the same genetic identity, the goal was to avoid any substantial divergence between the hatchery spring Chinook salmon and the natural-origin population in the Sandy River. In its 2011 ESA Status Review Update, NMFS confirmed that the spring Chinook salmon hatchery program was now integrated with the local natural population (Jones 2011). NMFS further determined that the Sandy Hatchery spring Chinook salmon were not substantially diverged from the natural population of spring Chinook salmon in the Sandy River and included them in the LCR Chinook salmon ESU (Jones 2011). From 2008 to 2010, up to 30 percent of the hatchery broodstock was composed of natural-origin spring Chinook salmon – this is also known as pNOB (i.e., the proportion of natural-origin fish in the broodstock) – with the remainder being made up of local-origin returning hatchery adults. Since 2011, only returning hatchery adults have been used for broodstock; under the No-action Alternative, the hatchery program would continue to use only returning hatchery adults for broodstock, thus maintaining pNOB at zero.

Under the No-action Alternative, the pHOS[2] goal for the Sandy Hatchery spring Chinook salmon program is less than 10 percent, based on a 3-year moving average. The less-than-10-percent pHOS goal is the threshold for spring Chinook salmon in the Sandy River Basin established in the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010a), and incorporated into NMFS' LCR recovery plan (NMFS 2013c). Under this management practice, the 3-year moving average, pHOS would never exceed 10 percent. A 3-year moving average is used because salmon and steelhead live under highly variable conditions (from freshwater to the ocean and back) and a single measure or snapshot in time does not provide the best indication of both the status of the fish and the factors that affect them.

NMFS would determine annually whether the pHOS goal has been achieved based on 3 years of data; however, if NMFS determines after one or two years (of the three-year moving average period) that the pHOS is so high that attainment of the pHOS goal, averaged across three years, would not be a reasonable expectation, then NMFS would declare that the threshold has been exceeded. As describe in Subsection 4.3, pHOS is an indicator of the genetic introgression between hatchery and natural-origin fish that can result from hatchery fish spawning naturally. As an indicator, the proportion of hatchery fish spawning naturally does not directly measure genetic introgression because not all hatchery fish will survive to spawn successfully, spawn with natural-origin adults, contribute equally to the spawning population, and/or produce off-spring (HSRG 2014; NMFS 2014b). Exceeding the threshold would trigger and intensive evaluation by ODFW and NMFS to look at these factors to determine the level of genetic introgression and to determine if changes to the hatchery program are required to minimize the effects.

[2] pHOS is defined in this document as the proportion of hatchery fish in the natural spawning population, or the "census pHOS". NMFS considers pHOS to be a conservative indicator of the effects on the natural spawning population. The proportion of hatchery fish that actually contribute progeny to the natural-origin population is likely smaller than the "census pHOS" because hatchery fish are not as effective as natural-origin fish at producing progeny (see Subsection 4.3, Effects on Anadromous Fish Listed under the ESA).

Under the No-action Alternative, weirs would be used to help control pHOS and to collect broodstock for the hatchery program (HSRG 2014; NMFS 2014b). After the removal of Marmot Dam in 2007, broodstock was collected from adults returning to the Sandy Hatchery, via seining, and through sport hook and line. Under the No-action Alternative, broodstock for the spring Chinook salmon program would be collected from volitional returns to the Sandy Hatchery and from adults collected at the temporary weirs in the Bull Run, Zigzag, and Salmon Rivers. The temporary weirs would be installed annually beginning in June and would be removed when natural-origin coho salmon begin to be encountered at the weirs in October. This is to minimize the effects on ESA-listed coho salmon. The weirs would be used to trap and remove all marked hatchery spring Chinook salmon to achieve the pHOS goal of less than 10 percent for the Sandy River Basin.

Weirs are essentially barriers (i.e., fences) to the upstream migration of fish where the fish are directed into a trap so they can be counted, sampled, and sorted (NMFS 2014b). There are two types of weirs that are generally used in the Northwest to sample and sort salmon and steelhead: rigid picket weirs and resistance board weirs (NMFS 2008a; 2010b; 2011c). A rigid picket weir is as it sounds: a rigid picket fence that spans the river to block upstream passage. The rigid picket weir is made up of panels or pickets that are spaced to prevent adult salmonids from squeezing through. The panels are supported on the downstream side by tri-pods that hold the panels at an angle such that the top is above the water surface preventing fish from passing over the weir. This type of weir is generally used in small rivers where the streambed is rough and not uniform, and the river flow is lower and less variable. Rigid picket weirs are susceptible to failure during high flow events and from debris building up on the upstream side of the weir.

Resistance board weirs are commonly used in larger rivers where flows are more variable. A resistance board weir consists of panels that are anchored on the upstream end to the stream bed via a cable and have a board that is affixed to the underside of the panel at the downstream end that pushes against the current raising the downstream end of the panel out of the water. The resistance board weirs also incorporate rigid picket weir panels in areas where resistance board panels are not needed, for example, outside the main current and where there are variations in the streambed. Resistance board weirs are designed to adjust to changing flow levels and, at normal high flows and debris loads, the resistance board panels can submerge and resurface once the flows drop or the debris has passed over the weir.

The Salmon River weir would be a rigid picket weir that is more favorable in this location because the substrate and streambed profile is not uniform from bank to bank and it favors a rigid picket weir's ease of installation and minimal long term footprint on the streambed (Lackey et al. 2013). The Salmon River rigid picket weir was installed in a new location beginning with the 2013 broodstock collection period. This location was downstream from the weir site used in 2011 and 2012 (Figure 1). The trap was moved to the new location in response to attraction flow issues experienced in the previous trapping season's location, as the former HGMPs called for adjustments to the weir location. The new trapping location is a glide with the trap located in the main channel of the river to increase the attraction flow to the trap entrance.

When constructing the new weir and trap, sand bags were placed extensively over every surface with potential of scour (under-cutting due to the current) occurring to prevent any fish from

passing the rigid picket weir or trap undetected. Sandbags were checked daily using a mask and snorkel to ensure no holes were present for fish to pass undetected. The trap is approximately 12 feet in length and 7.5 feet wide and 5 feet tall and completely enclosed. The trap has a swinging access door 2 feet by 2.5 feet to access the fish and pass them safely upstream. The swinging door is locked when not in use to prevent poaching and harassment of fish in the trap. A black fabric was placed on the inside roof of the trap to prevent any fish from jumping into the roof and to help provide a dark resting place. Foam padding was placed in every inside corner of the trap, around all entrance door corners, and trap edges and corners to prevent any physical damage from occurring to fish while inside the trap. Two sections (3 feet by 3 feet) of plywood were placed on the upstream wall. The plywood sections allow fish to rest while inside the trap, while maintaining attraction flow through the trap entrance.

The design and installation of the Zigzag River weir is the same as the Salmon River weir, described above. The Zigzag River weir has been in the same location since 2011 (Figure 1) (Lackey et al. 2013).

The Bull Run River weir is a resistance board weir instead of a rigid picket weir due the wide range of flows in the Bull Run River, compared to the other two locations. The Bull Run trap is much larger than the other two traps at 15 feet long by 10 feet wide and 6.7 feet tall. A resistance board weir was installed at this location because it is viewed as a longer-term trapping solution, and the larger trap box will allow large numbers of fish to hold in the trap as more hatchery spring Chinook salmon are expected to home[3] to this location from releases from the Bull Run acclimation pond located upstream of the weir (Figure 1)(Lackey et al. 2013). The resistance board weir requires more site preparation and fabrication than the rigid picket weirs but works well in large stream systems. The resistance board weir panels are fixed to the stream bottom through the placement of a substrate rail that is perpendicular to the flow.

The installation would require the movement of cobble and boulders by hand/pry-bar to have a relatively smooth bottom to place the substrate rail, and no mechanized equipment would be used to move instream material. A cable is run through eyebolts attached to the substrate rail and the individual weir panels are attached to the river bottom by the cable. The substrate is also favorable at this location for a resistance board weir because of its uniform composition and low potential for scour or channel movement. As with the other two weirs, sand bags were placed extensively over every surface with potential of scour occurring to prevent any fish from passing the floating resistance board weir or trap undetected. Sandbags were checked daily using a mask and snorkel to ensure no holes were present for fish to pass undetected. Black fabric was placed around all walls to provide shade for trapped fish. Foam padding was placed on every inside corner of the trap, around all entrance door corners, and trap edges and corners to prevent any physical damage from occurring to fish while inside the trap (Lackey et al. 2013).

Under the No-action Alternative all natural-origin spring Chinook salmon adults trapped would be enumerated and promptly passed upstream of the weirs. The traps would be monitored at least

[3] "Homing" and "to home" are terms used to describe the tendency observed in salmon and steelhead to return to the same tributary or location where they were reared and released as juveniles (Quinn 1984; Dittman and Quinn 2008)(see acclimation discussion in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA).

daily, but more frequently during periods when larger numbers of spring Chinook salmon are expected to encounter the traps (usually early September). At all of the weir locations, temperature and dissolved oxygen are recorded daily and often multiple times when the traps are checked twice in 1 day. ODFW has estimated that the maximum number of natural-origin spring Chinook salmon handled annually at the three weirs combined would be 2,750 adults. Included in this total, are up to 50 natural-origin spring Chinook salmon that could volunteer into the Sandy Hatchery, these fish would be returned unharmed to the Sandy River to spawn naturally.

Under No-action Alternative, hatchery-origin broodstock would be collected at Sandy Hatchery through volitional returns, and from seining/tangle net activities or the weirs located throughout the basin. The broodstock needed to meet the current production goal is 200 hatchery-origin adults, and includes extra adults to account for pre-spawning mortality. Anglers and volunteers may also assist ODFW staff with hatchery brood collection utilizing hook and line in the lower Sandy River, primarily from Oxbow Park downstream to Lewis and Clark State Recreational Area.

Volunteers employed to collect spring Chinook salmon would be required to enroll with ODFW and receive special instruction on proper handling and transport of fish collected. Anglers would also receive specific written instructions, and written authorization to hold and transport hatchery fish for the broodstock program. An evaluation of the various methods of broodstock collection (e.g., seines/tangle-net, weirs, traps) would be included in this analysis.

The inability to trap and remove hatchery spring Chinook salmon since the removal of Marmot Dam contributed to the high proportion of hatchery spring Chinook salmon spawning naturally, or pHOS, in return years 2008 to 2011 (Table 6). This proportion has exceeded the less-than-10 percent goal for the natural-origin Sandy River spring Chinook salmon population that was identified in the Recovery Plans (ODFW 2010a; NMFS 2013c). Under the No-action Alternative, the operation of the weirs and the possible use of seines and tangle-net to collect broodstock also have an additional goal of removing hatchery spring Chinook salmon from the naturally spawning population (Schroeder et al. 2013). The operation of the weirs along with other hatchery management actions has been shown to reduce pHOS such that the less-than-10 percent goal was achieved for the first time in 2013 (Whitman et al. 2014b). Under the No-action Alternative, the pHOS goal of less than 10 percent would be based on a 3-year moving average beginning with returns in 2013 (this is the first year that the HGMPs were in effect).

The effects on natural-origin spring Chinook salmon that are handled and released during collection activities have been as expected and are further described and analyzed below (Section 4, Environmental Consequences). Monitoring activities described below are used to monitor the status of the naturally spawning population to determine whether the pHOS goal is being achieved and if the operation of the weirs is adversely impacting the naturally spawning population.

Adults collected for broodstock and all other hatchery adults would be removed from the system and transported to the Clackamas Hatchery and/or the Sandy Hatchery. Uses for excess hatchery spring Chinook salmon include, but are not limited to, supplying fish for tribal ceremonial and subsistence use, carcass sales to generate revenues to support the programs, donations to

charitable food share programs, and placement of carcasses in natural spawning and rearing areas to provide marine-derived nutrients. The broodstock would be held at the Clackamas Hatchery until spawning. After spawning, the eggs would be reared to eyed stage at Clackamas Hatchery.

Clackamas River water is limited by water quality (pathogens) during summer months. Exposing eggs, fry, and fingerlings to untreated river water may create a disease transmission concern. To avoid these problems, eyed-eggs would be shipped to Willamette Hatchery for final incubation and early rearing, and marking (otolith, coded-wire tag [CWT], and adipose fin-clip). The fingerlings from Willamette Hatchery would then be transferred (at about 200 fish per pound (fpp)) to Leaburg Hatchery for further rearing. All program fish from Leaburg Hatchery would then be sent to the Sandy Hatchery in the late fall-early winter (at around 18 fpp) for final rearing to smolt size.

The operation of the Willamette and Leaburg Hatcheries was evaluated in a separate ESA consultation and determined not to jeopardize listed salmon and steelhead in the Upper Willamette River Basin (COE and NMFS 2008). Mitchell Act funds are used to support the Sandy River spring Chinook salmon program at the Clackamas Hatchery and funds feed to support rearing at Willamette Hatchery and Leaburg Hatchery. The operation of the Willamette and Leaburg Hatcheries is not evaluated as part of this analysis because these facilities would continue to be operated in a similar manner without the addition of the production and associated funding from the hatchery program.

The spring Chinook salmon would be reared at Sandy Hatchery until the following spring and then transferred to the Bull Run acclimation pond at 10 to 12 fpp. This is the only proposed release site for this program. Under the No-action Alternative, the annual production goal for this program is 300,000 smolts.

The Clackamas Hatchery is located at RM 22.6 on the Clackamas River in the Willamette River Basin, Clackamas County, Oregon. The Clackamas Hatchery uses well water and water removed from the Clackamas River under permits issued by the state of Oregon (numbers S49433 and S42105). Well water is withdrawn under permit number G8257. Water rights to Clackamas River water for the hatchery total 44,354 gpm. Chinook salmon are incubated and reared in 52°F well-water or with Clackamas River water that is pumped to the facility and treated with ultraviolet light (UV). The river water intake is 100-percent-screened with 3/16” mesh. Fish screens have been inspected (ODFW 2002) and were deemed non-compliant with current NMFS fish screening criteria. Discharge water is currently covered under a NPDES individual permit number 102663.

The Bull Run acclimation pond is located at RM 1.5 on the south bank of the Bull Run River immediately adjacent to the decommissioned Bull Run Powerhouse (Figure 1); it began releasing hatchery spring Chinook salmon in 2011. The temporary pond (10 feet wide x 60 feet long x 4 feet 9 inches tall) is above ground and constructed of poly-vinyl lining within a galvanized steel frame. The water source for the Bull Run acclimation pond is the Bull Run River. Water (450 to 600 gpm) is supplied by a 7.5 to 10 horse power (hp) pump with the intake screened to NMFS criteria (3/32 inch mesh w/spray wash cleaning system). The 6-inch intake pipeline carries water up to the pond (approximately 20 feet above the river) and an 8-inch outfall pipeline falls back

down to a deep pool adjacent to the intake. An NPDES permit is not needed for the acclimation pond because the production levels are below the minimum criteria for a permit.

Smolt releases are targeted for mid-March (see Table 10.3 of the HGMP (ODFW 2011a)). Typically, a portion (approximately 100,000) of the total smolt production would be acclimated at Bull Run acclimation pond for 2 to 3 weeks and then released. The next group of smolts would be acclimated for a 2 to 3 week period after the first release group goes out. The release would occur by removing the standpipe from the pond causing the water level in the pond to drop. A crowder (e.g., seine net or some other device to move fish to one area of the pond) would be used to move the smolts towards the water outlet for release (see Section 10.6 of the HGMP (ODFW 2011a). Exact release dates would vary based on fish status (primarily weight and condition), river flow conditions, onset of water quality problems, transfer scheduling, and logistical constraints for rearing other stocks.

Sandy Hatchery spring Chinook salmon smolts are fin marked (adipose fin-clip) to differentiate between natural and hatchery-origin fish. The mean detectable mark rate is approximately 97 percent. All smolts released also receive an internal otolith mark that allows for identification of mis-marked hatchery-reared fish (i.e., hatchery fish that did not get an adipose fin clip). All spring Chinook salmon smolts released in the Sandy Basin would also receive an internal coded wire tag (CWT) to further assist in identification.

Spring Chinook salmon spawning ground surveys in the Sandy River Basin would consist of carcass recovery and redd counts. These activities have been funded with Sport Fish Restoration funds in the past and are currently funded under the Mitchell Act. These surveys are designed to be a complete census of the primary spawning areas in the upper Sandy River Basin. Conducting surveys in the mainstem Sandy River would be problematic because of limited visibility from glacial meltwater. Because of this the Sandy River mainstem has been surveyed with less intensity and consistency through the years and is dependent on water clarity.

Surveys in the Little Sandy River were initiated in the 2008. Data collected from carcasses would include pre-spawning mortality (based on females), hatchery and natural-origin composition (based on presence or absence of fin clips, CWT tags or thermal marks in otoliths), and age composition and freshwater life history in natural-origin fish (based on analysis of scales). Redd counts would be used to estimate spawner escapement, run size, and spawning distribution. Because of the placement of the weirs in the Salmon and Zigzag Rivers, surveys would record live fish, carcasses, pre-spawning mortality, hatchery and natural-origin composition, and redds upstream and downstream of the weirs.

To confirm that hatchery smolts released from the Bull Run acclimation pond and the Sandy Hatchery (coho salmon and steelhead) are promptly leaving the Sandy River Basin for the Pacific Ocean, under the No-action Alternative, ODFW would monitor smolt outmigration. The preferred habitat of juvenile salmon and steelhead would be sampled at multiple locations. ODFW would use various non-lethal sampling techniques, including seine nets, electrofishing, snorkeling, and angling to survey the abundance, and spatial distribution of juvenile hatchery fish. Two sample periods would occur, the first approximately 21 days after the second release of Chinook salmon smolts from the Bull Run acclimation pond and the second, 21days after the last

release of winter steelhead smolts from the Sandy Hatchery. Based on sampling in 2013, ODFW estimates that up to 1,000 Chinook salmon juveniles, 1,000 coho salmon juveniles, and 100 steelhead juveniles could be handled annually.

2.1.2. Sandy River Coho Salmon Program

The Sandy River Coho Salmon program as described in the HGMP (ODFW 2011b) is an on-going program that was approved under the Concurrence Letter (NMFS 2012d) and described in the September 28, 2012, Biological Opinion and Incidental Take Statement (NMFS 2012b). Under the No-action Alternative this program would continue to release up to 500,000 in-basin origin hatchery coho salmon smolts (designated as Oregon stock 11) to augment lower Columbia River commercial and recreational fisheries, the Sandy River recreational fishery, and the Pacific Ocean commercial and recreational fisheries. Mitchell Act funds for fiscal year 2013 were provided to ODFW for monitoring and evaluation activities in the Sandy River Basin. The operation of the Sandy Hatchery facility is funded by ODFW through license sales.

Although no numeric harvest goal for this program has been adopted, the average smolt-to-adult survival rates of 1.75 percent (Table 1.12a of the HGMP (ODFW 2011b)) have provided good opportunities for commercial and recreational fishing in the Pacific Ocean, the Lower Columbia River and the Sandy River Basin. Sandy River harvest of program coho salmon has averaged 3,872 from 2000 to 2009, and the harvest in all fisheries combined has averaged 7,856 adult for brood years 2002 through 2006 (ODFW 2011b). ODFW expects that harvest would less than in the past under this alternative because releases from those brood years that contributed to the harvest averaged over 737,000 smolts compared to the current annual release goal of 500,000 smolts. This program used to provide eggs to support an annual release of 420,000 smolts by the Clatsop County Fisheries (CCF) to support a terminal gill-net fishery in Youngs Bay and Blind Slough and for recreational and commercial fisheries in the lower Columbia River. The collection of broodstock for this program ended in 2011.

ODFW manages harvest of Sandy Hatchery coho salmon to comply with the FMEP that explains the management implications for holding a recreational fishery where hooking mortality of listed fish may occur. The FMEP for LCR coho salmon fisheries has been submitted to NMFS. Since 2003, relatively small changes in fisheries management have occurred relative to the assessment by NMFS (NMFS 2007b); the effects of those refinements are considered in Section 4, Environmental Consequences.

Based on observed encounter and hooking mortality rates, ODFW estimates a maximum Sandy River Basin fishery impact of 3 percent for all fall tributary salmon fisheries. Current recreational fishing regulations for the Lower Columbia River ESU require that all unmarked coho salmon be released back to the water unharmed. Only adult coho salmon marked with an adipose fin clip may be retained in recreational fisheries (ODFW 2011b). Recreational fishing for coho salmon in the Sandy River is open year-around with regulations requiring the release of any unmarked fish to protect natural-origin coho salmon that tend to migrate into tributaries in November and December. Direct harvest of natural-origin coho salmon may occur in commercial fall gill-net fisheries in the mainstem Columbia River that target returning hatchery coho salmon. Fisheries are managed to limit impacts to levels developed during the ocean fisheries management process and are these levels are based on the ocean survival and broodyear

abundance of natural-origin coho salmon from the populations in the Sandy and Clackamas Rivers (NMFS 2008c; 2008g).

The effects of the No-action Alternative on the fisheries in the Sandy River are included in this analysis. The effects of the No-action Alternative on fisheries outside the Sandy River Basin (Ocean and Columbia River mainstem fisheries) would not be discernible because Sandy River hatchery production accounts for only a small percentage of the total coho salmon available to the ocean and mainstem fisheries (NMFS 2008c; ODFW and WDFW 2011), and thus will not be considered further in this analysis.

From its inception with the 1952-1953 return year, and until recently, the Sandy River coho salmon hatchery program has integrated natural-origin local coho salmon into the hatchery broodstock (ODFW 2013c). Since 1998, all hatchery coho have been mass marked, and naturally produced coho salmon are no longer incorporated into the broodstock (i.e., pNOB is zero). However, hatchery coho salmon have not substantially diverged from the natural population, are still integrated with the natural population, and the hatchery program is still included in the LCR Coho Salmon ESU (NMFS 2004b; Jones 2011). NMFS (2003a) determined the degree of genetic divergence between the hatchery stock and the natural population(s) that occupy the watershed into which the hatchery stock is released, as well as the origin of the hatchery stock and the status of the natural population in the watershed for the entire Columbia River Basin.

Under the No-action Alternative, the pHOS goal for the Sandy Hatchery coho salmon program is less than 10 percent, based on a 3-year moving average. Because coho salmon from the hatchery program have not substantially diverged from the natural-origin population, the less-than-10 percent pHOS goal was established for this program. This goal is consistent with the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010a) and NMFS' LCR recovery plan (NMFS 2013c). There is a limited number of returning hatchery adults that migrate into the Sandy River upstream past the mouth of Cedar Creek but the number has been limited to less than 5 percent of the natural spawning population in the upper Sandy Basin as measured at the former Marmot Dam. ODFW evaluations have identified that a majority (greater than 70 percent) of natural spawning habitat for coho salmon in the Sandy River Basin exists above the former Marmot Dam site, with the vast majority of habitat in the upper basin being found in the Salmon and Still Creek/Zigzag Rivers. A small portion (less than 30 percent) exists in the lower mainstem and tributaries including the Bull Run River, Little Sandy River, Cedar Creek, Gordon Creek, Trout Creek, and Beaver Creek.

The Sandy River coho salmon hatchery program is managed as a segregated (also sometimes referred to in NMFS documents as an isolated) hatchery program and would continue to be under the No-action Alternative. Broodstock for this program would be collected from returns to the Sandy Hatchery. The annual broodstock collection goal is 450 adults (200 to 250 females and 200 to 150 males) for the 500,000 smolt release. The number of hatchery coho salmon smolts released into the Sandy River has declined from 1,000,000 smolts in the 1990s, to 750,000 through 2009, to the current level of 500,000 smolts since broodyear 2008 (ODFW 2011b). An adult weir on Cedar Creek is used to direct all returning adult coho salmon into the adult holding ponds where they can be sorted. All unmarked coho salmon (assumed to be natural-origin) are

sampled for CWT and, if not tagged, are allowed volitional passage into upper Cedar Creek to spawn naturally. ODFW estimates that up to 600 natural-origin coho salmon could be handled annually. All hatchery fish that enter the hatchery trap are collected and are either selected for broodstock or provided to the Oregon Food Bank or local food banks if in good condition. Those that are not provided to the food banks are utilized in nutrient enrichment programs for local streams. All hatchery coho carcasses used for enrichment of spawning streams are marked to prevent confusion with monitoring of naturally spawned fish.

The broodstock collected at the Sandy Hatchery would be held and spawned on-station. The hatchery intake on Cedar Creek is 100 percent screened throughout the year. The upgraded intake structure and the adult weir at the hatchery outfall were designed to provide upstream and downstream juvenile and adult passage. ODFW would maintain minimum flows between intake structure and the hatchery outfall would be maintained to allow for juvenile passage in this section of Cedar Creek. Over 230 coho salmon were passed for the first time in over 50 years during the fall of 2010. All unmarked coho salmon and winter steelhead would be transported upstream of the hatchery for release until natural flows would allow for volitional release above the adult weir after sorting of marked and unmarked fish.

After spawning, the coho salmon would be reared to full term on-station and released at Sandy Hatchery. In the past (2010 and 2011 broodyears), the hatchery coho salmon were reared off-station for the summer months at the Bonneville and Cascade Hatcheries. ODFW staff were concerned that the transition to off-station rearing could increase the level of stray hatchery coho salmon in the Sandy River, which historically has been very low based on former Marmot Dam counts and spawning surveys from 2007 to 2010. This concern directed ODFW's management decision to rear the hatchery coho salmon on-station even though low flows in Cedar Creek that can occur during the late summer and early fall (primarily September) may impact rearing conditions at the hatchery.

During the spring, when acclimating and releasing juvenile fish on-station, the Sandy Hatchery removes up to 11,200 gpm (out of the 12,577 gpm water right), and during September, when coho salmon broodstock collection begins, the hatchery uses around 2,300 gpm. The water flows through the hatchery and exits through the adult holding ponds back into Cedar Creek. Rearing the coho salmon at the Sandy Hatchery would require a minimum water withdrawal from Cedar Creek of 2,200 gpm through August and 2,300 gpm through September. These withdrawals would be expected to leave between 1,300 and 1,400 gpm in Cedar Creek to provide for juvenile rearing and passage flows, but not provide for adult passage through the by-pass reach between the intake and the hatchery outfall. During this period natural-origin coho salmon that enter the hatchery would be transported and released above the hatchery intake structure to continue their migration. Once flows increase during the fall, natural-origin coho salmon would be released into Cedar Creek above the adult weir.

The coho salmon would be reared at the Sandy Hatchery until March when they would reach 18 fpp. Smolts would then be transferred from the raceways to the adult holding pond and allowed to recover for approximately 24 hours prior to release. The fish would then be released from the adult holding pond by removing screens and partially lowering the water level in the pond to facilitate a gradual release and dispersed downstream migration of smolts. Fish would be

allowed to volitionally migrate from the pond for a 24 hour period. After 24 hours water levels in the pond would be gradually dropped further to promote migration. After approximately 48 hours, water levels would be dropped fully, and any remaining fish would be transported into Cedar Creek. Based on long-term observations, almost all coho smolts out-migrate volitionally during the first 24 hour period after screen removal (ODFW 2011b).

All of Sandy Hatchery coho salmon smolts would be fin marked and/or tagged with a CWT to differentiate between natural and hatchery-origin fish. Sandy Hatchery coho salmon would be fin marked with an adipose fin-clip. Approximately 25,000 non-adipose fin-clipped coho smolts would be released annually with a CWT but with no external mark identifying it as a hatchery fish, to serve as a double index group that is used to estimate fisheries impacts on natural-origin adults. Spawning surveyors, hatchery staff, and weir/trap operators utilize CWT detectors on all fish surveyed/handled to ensure proper identification of unmarked hatchery fish.

The ODFW proposes to monitor the recolonization of coho salmon and winter steelhead in Cedar Creek above the Sandy Hatchery. Monitoring in Cedar Creek would be coordinated with the U.S. Forest Service and Portland Water Bureau efforts to monitor coho salmon and steelhead smolt production throughout the Sandy River Basin (Strobel 2014). The study is intended to detect increases or declines in abundance and productivity of smolts at the basin scale and to provide useful data at the scale of individual tributaries to guide restoration efforts. The sampling design for the larger study involves monitoring different sets of tributaries every year, with some tributaries monitored every year and others monitored on an irregular rotating basis. Cedar Creek has been identified as one of the trapping locations in this study that would receive yearly monitoring.

Downstream migrants would be trapped in a 5-foot rotary screw trap (i.e., migrant trap) located in the mainstem Cedar Creek upstream of the Sandy Hatchery. The specific site has yet to be determined. The migrant trap would be located in the thalweg (main channel) of a site that would maximize both the flow into the trap and the amount of stream the trap would fish. Because of seasonal variation in streamflow, the trap would be periodically repositioned in the stream channel in order to optimize trapping efficiency. The trap would be fished seven days a week annually from March to June, except when pulled during high-flow events or under other circumstances to prevent fish injury.

The migrant trap would funnel downstream migrants into a live box that would be sampled on a daily basis, usually in the morning to reduce temperature-related stress. All fish would be anesthetized with MS-222 (tricaine methanesulfonate) or Alka-Seltzer Gold[4] (buffered sodium bicarbonate), examined for mark combinations, and counted by species and life stage. All or a random sample (depending on numbers of fish) of salmonids would be sampled for scales and tissue samples, measured to the nearest millimeter fork length, and weighed to the nearest 0.1 gram.

[4] These drugs are used in isolated containers and, after sampling, the contents are removed from the environment per manufacturers' guidelines and, thus, no impacts on the environment would be expected.

Mark-recapture methodologies would be used to estimate numbers of anadromous salmonids smolts migrating past the trap. Up to 25 smolts per day of each species would be given a fin mark (small clip or injected dye) specific to the day of the week. Marked fish would be temporarily held in dark, aerated buckets for transport and release upstream from the trap (site yet to be determined) daily. ODFW proposes to sample up to 5,000 natural-origin coho salmon smolts annually during monitoring activities in Cedar Creek, approximately 200 of these would be tissue sampled. It should be noted that the monitoring of coho salmon and steelhead smolts in Cedar Creek would probably occur even if the hatchery programs are not present.

Coho spawning ground surveys would be conducted in the Sandy River as part of the larger Status of Oregon Stocks of Coho Salmon Project (Lewis et al. 2009; Lewis et al. 2010; Lewis et al. 2011). This project is part of the larger Oregon Plan for Salmon and Watersheds and funded in part through the Sport Fish and Wildlife Restoration Program, Pacific Salmon Treaty, Pacific Coast Salmon Recovery Fund, and State of Oregon (General and Lottery Funds) (Lewis et al. 2011).

The coho salmon spawning ground surveys would be conducted weekly from October through January of each year. Crews would conduct surveys by walking up-stream and recording the number of live fish, dead fish, and redds observed and categorical information on weather, visibility, and stream flow. Surveyors would record the species of live fish observed, and for coho salmon, try to determine if the adipose fish has been clipped. For carcasses, surveyors would collect biological data along with mark information (fin-clips, marks, or tags). The data collected during the spawning ground surveys would be used to develop estimates of spawning escapement and the proportion of hatchery coho salmon spawning naturally (Lewis et al. 2011).

2.1.3. Sandy River Winter Steelhead Program

The Sandy Hatchery winter steelhead program as described in the HGMP (ODFW 2011d) is an on-going program that was approved under the Concurrence Letter (NMFS 2012d) and described in the September 28, 2012 Biological Opinion and Incidental Take Statement (NMFS 2012b). Under the No-action Alternative this program would continue to release up to 160,000 in-basin origin hatchery winter steelhead smolts (designated as Oregon stock 11) with the intent to provide a recreational fishery with fish that are similar to the natural-origin fish in the Sandy River to maintain a quality fishery that meets public demand and satisfies the desires of anglers while minimizing potential risks to natural-origin spring Chinook salmon, coho salmon, and winter steelhead populations, consistent with the Recovery Plan (ODFW 2010a; 2011d). Mitchell Act funds for fiscal year 2013 were provided to ODFW for monitoring and evaluation activities in the Sandy River Basin, and hatchery production at other facilities (as described below). The operation of the Sandy Hatchery is funded by ODFW through license sales.

There are no specific numeric goals for harvest contribution for the winter steelhead program, but the program has been changed to increase fishing opportunity in the Sandy River Basin. Prior to 2000, Big Creek Hatchery winter steelhead were released into the basin. This stock tended to have a narrow adult return timing: from mid-November to mid-January. The winter steelhead currently used for broodstock have a more protracted return time from January to May, allowing for greater fishing opportunities. The major concern regarding the recreational fishery is its potential impact on the listed population of winter steelhead. Subsection 2.1 of the FMEP for the

Lower Columbia DPS Steelhead (ODFW 2003) provides an evaluation of this recreational fishery where catch and release mortality can occur. The harvest of Sandy River hatchery-origin winter steelhead, supported by the proposed hatchery program, is managed to comply with this FMEP (see the evaluation of the FMEP in (NMFS 2003b)). Since 2003, relatively small changes in fisheries management have occurred relative to the assessment by NMFS (2003b); the effect of those refinements would be considered in Section 4, Environmental Consequences.

Current fishing regulations for the Lower Columbia River Steelhead DPS require that all unmarked steelhead be released back to the natural-origin unharmed (ODFW 2011d). There is no retention of unmarked, listed steelhead in the DPS with the exception of a fishery, where retention is allowed, from July 1 through August 31 in the upper Sandy River upstream of and including the Salmon River. This fishery is intended to harvest marked and unmarked (non ESA-listed) naturally produced summer steelhead that are not indigenous to the Sandy River Basin. Only adult steelhead with an adipose fin clip may be retained in recreational fisheries targeting winter steelhead in the lower river downstream of the mouth of the Salmon River. Prior to the removal of Marmot Dam winter steelhead fishing was limited to below the dam site and averaged 1,368 adults annually from 2003 to 2007 (ODFW 2011d). After the dam was removed, the fishery was extended upstream to the mouth of the Salmon River with the goal of removing hatchery steelhead that would have been removed at Marmot Dam. The catch has increased to an average of 2,044 adults in 2008 and 2009 (ODFW 2011d).

The effects of the No-action Alternative on the fisheries in the Sandy River would be included in this analysis. The effects of the No-action Alternative on fisheries outside the Sandy River Basin (Columbia River mainstem fisheries) would not be discernible because Sandy River hatchery production accounts for only a small percentage of the total winter steelhead available to the mainstem fisheries (NMFS 2008c; ODFW and WDFW 2011), and thus will not be considered further in this analysis.

This program was developed by using only naturally produced Sandy River winter steelhead in the hatchery brood from 2000 to 2002 (ODFW 2013e). Since the mid-1980s and prior to brood year 2000, all hatchery releases of winter steelhead into the Sandy River were out-of-basin Big Creek Hatchery stock. The first release of hatchery smolts from the integrated Sandy River stock was in the spring of 2001 (ODFW 2013e). Integration with the local population was complete by 2004 when the annual broodstock collection goal shifted to include up to 30 percent natural-origin winter steelhead (i.e., pNOB of 30 percent) with the remainder of the broodstock comprising hatchery returns that were included in the ESA-listed DPS. In 2012, 2013, and 2014, only returning Sandy hatchery winter steelhead were used for broodstock. Under the No-action Alternative only returning hatchery winter steelhead would be used for broodstock.

The pHOS goal for hatchery winter steelhead that escape the recreational fisheries is less than 10 percent (based on a 3-year moving average) and is consistent with the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010a), and NMFS' LCR recovery plan (NMFS 2013c). Prior to removal of Marmot Dam in 2007, returning hatchery-origin adults were segregated from the natural spawning population through sorting operations at the Marmot Dam and only naturally produced fish were allowed to pass upstream to the primary winter steelhead spawning areas of the upper Sandy River Basin.

ODFW evaluations have identified that a majority (approximately 70 percent) of the remaining natural spawning habitat for winter steelhead in the Sandy basin exists in the primary production areas above the confluence of the Salmon and upper Sandy Rivers.

Broodstock collection for this program would be provided by adult winter steelhead swimming into the adult trap at Sandy Hatchery. Adults would be allowed to swim-up the fish ladder from Cedar Creek and into a pre-sort holding pool within the fish ladder or in the entrance pen of the adult holding pond. These returning fish would be handled individually in soft mesh nets, identified, sorted by gender, counted and held for later spawning. The adults may be held in a raceway for up to three months prior to spawning in March/early April. Hatchery adults would be Floy tagged (an alpha-numeric external tag, available in multiple colors, that is anchored under the skin and can be read without removal), as they are collected for brood to document their time of return and may be removed from the broodstock population later in order to match the return timing of the broodstock with the natural run-timing of natural-origin winter steelhead in the Sandy River. Natural-origin coho salmon and winter steelhead that enter the trap at the Sandy Hatchery would be sorted and allowed to pass upstream of the hatchery into Cedar Creek. ODFW has a minimum escapement goal of 300 adult winter steelhead (50 percent female and 50 percent male) above the Sandy Hatchery in Cedar Creek, but cannot currently meet this minimum because less than 25 adults natural-origin steelhead are collected annually. Under the No-action Alternative ODFW proposes to pass hatchery winter steelhead to achieve the escapement goal and would reduce the number of hatchery winter steelhead released as natural-origin winter steelhead adults returning to Cedar Creek increase. ODFW estimates that in the future they may handle up to 200 natural-origin winter steelhead at the hatchery annually.

Under the No-action Alternative, the program goal is to collect 120 adults (60 pairs) of hatchery-origin winter steelhead for broodstock. All hatchery winter steelhead that would be surplus to broodstock needs at Sandy Hatchery would be either recycled to the lower river for additional angling opportunities, released upstream to meet the escapement goal, given to food banks (e.g., Oregon Food Bank) if in suitable condition, used for stream nutrient enrichment, or disposed of if not fit for human consumption. Disposal of fish would be done in accordance with ODFW policies and procedures, which include freezing, rendering, and/or placing in a landfill.

Fish that return to Sandy Hatchery in a condition suitable for angler use from December through mid-February may be recycled once through the lower river fishery to provide additional angling opportunities. Recycled fish would be released at Lewis and Clark Recreational Area. All recycled fish would be distinctly marked (e.g., caudal punch [the removal of a small portion of the caudal fin using a hand-held paper punch] or Floy tag) prior to release. Fish would only be recycled once; all fish that are collected a second time would be permanently removed from the Sandy River either by killing the fish or transferring them to isolated standing waters (e.g., Salish Ponds) to provide additional angling opportunity associated with trout fisheries. No fish would be recycled to the lower river after February 16. Recycling would be discontinued if stray rates exceed the level established in the Recovery Plan (ODFW 2010a).

The broodstock collected at the Sandy Hatchery would be held and spawned on-station. The program goal is to collect 210,000 green eggs to produce 160,000 smolts. After spawning, the eggs would be reared on-station to the eyed-egg stage and then transferred to Oak Springs

Hatchery in May. Oak Springs Hatchery is located at RM 47.0 on the Deschutes River in the Deschutes River Basin, Wasco County, Oregon. The water source for the Oak Springs Hatchery is Oak Springs, a tributary to the Deschutes River. Water rights provide for 53 cfs from 15 different certified points of the spring. The present water delivery system can deliver approximately 24,062 gpm to the hatchery. Intake screens at the hatchery do not meet current NMFS screening criteria but no ESA-listed species are known to exist in the water source. Discharge water is currently covered under NPDES individual permit 300-J General Permit number 64515.

After rearing at Oak Springs Hatchery, the winter steelhead would be transferred to Bonneville Hatchery for further rearing. Bonneville Hatchery is at RM 0.25 on Tanner Creek a tributary to the lower Columbia River near Bonneville Dam in Oregon. The intake screens at Bonneville Hatchery meet NMFS screening criteria (NMFS 2011a). Hatchery effluent is managed to comply with conditions and water quality limits outlined in the existing NPDES permit 64425. Bonneville Hatchery receives approximately 165,000 fingerlings (30fpp) from Oak Springs Hatchery. All Sandy hatchery winter steelhead smolts are adipose fin-marked at the Bonneville Hatchery and then reared through March to about 6fpp prior to transfer back to Sandy Hatchery for final acclimation and release into the Sandy River. Mitchell Act funds are used to support the production of Sandy River winter steelhead at the Oak Springs and Bonneville Hatcheries. The operation of the Oak Springs and Bonneville Hatcheries are not be evaluated as part of this analysis because these facilities would continue to be operated and funded in a similar manner without the addition of the production from the proposed hatchery program.

The fish would be acclimated for at least 2 to 3 weeks prior to release. Smolts would be transferred from the raceways to the adult holding pond and allowed to recover for approximately 24 hours prior to release. The fish would then be released from the adult holding pond by removing screens and partially lowering the water level in the pond to facilitate a gradual release and dispersed downstream migration of smolts. Fish would be allowed to volitionally migrate from the pond for a 24-hour period. After 24 hours, water levels in the pond would be gradually dropped further to promote migration. After approximately 48 hours, water levels would be dropped fully and any remaining fish transported into Cedar Creek. Based on long-term observations, approximately 80 to 90 percent of the steelhead smolts volitionally migrate during the first 24-hour period after screen removal, and nearly all have migrated by the end of the 48-hour period; usually less than 1,000 smolts remain after 48 hours.

ODFW proposes to monitor winter steelhead juvenile production in Cedar Creek to evaluate the recolonization efforts. The same monitoring and evaluation activities described for the coho salmon program, above, would also be used to sample winter steelhead. ODFW proposes to sample up to 3,500 natural-origin winter steelhead smolts annually, and of these approximately 500 would be tissue sampled. The monitoring of coho salmon and steelhead smolts in Cedar Creek would probably occur even if the hatchery programs are not present.

Monitoring of spawning winter steelhead has been conducted by ODFW in the Sandy River in 2004, 2006, 2007, and 2010-2012. The project used methods developed by ODFW on the Oregon Coast and is designed to assess the yearly status and trend, presence of hatchery fish, and distribution of winter steelhead spawners within the basin. Winter steelhead abundance would be

based on counts of redds instead of live or dead fish. Selected sites would be visited approximately every 14 days from February through May to generate a total redd count. The proportion of hatchery spawners would be based on a combination of live counts and recovered carcasses observed within survey sites. Steelhead carcass recoveries are rare, and, as a result, live observations are the primary data source for hatchery stray estimates. Prior to 2013, live observations in the Sandy River have been below the levels needed to accurately depict the distribution of hatchery steelhead in the Sandy River Basin due to high turbidity and high flows that make viewing difficult resulting in questionable estimates for pHOS and abundance. In 2013, ODFW increased the intensity of surveys from once every 14 days to once every 7 days to increase the number of live fish observed (to determine if the fish are adipose fin-clipped or natural-origin) which has increased the accuracy of the pHOS and abundance estimates (ODFW 2013e).

2.1.4. Sandy River Summer Steelhead Program

The Sandy River summer steelhead program as described in the HGMP (ODFW 2011c) is an on-going program that was approved under the Concurrence Letter (NMFS 2012d) and described in the September 28, 2012, Biological Opinion and Incidental Take Statement (NMFS 2012b). The No-action Alternative would continue this program that is designed to provide fish for harvest. The Sandy Hatchery summer steelhead hatchery program is funded and operated to mitigate for habitat impacts and lost steelhead production. Fish from the program are intended to be caught in recreational fisheries and to provide enough broodstock to perpetuate the hatchery program. Hatchery summer steelhead are not intended to spawn naturally. Mitchell Act funds for fiscal year 2013 were provided to ODFW for monitoring and evaluation activities in the Sandy River Basin, and hatchery production at other facilities (as described below). The operation of the Sandy Hatchery is funded by ODFW through license sales.

This program aims to provide for harvest in the lower Columbia River and the Sandy River recreational fisheries. Although no numeric harvest goal has been adopted for this program, the average smolt-to-adult survival of summer steelhead in the past 10 years (2.12 percent) (HGMP Table 1.12 (ODFW 2011c)) has provided for good angling opportunities in the Lower Columbia and Sandy Rivers. The numeric goal for this popular summer steelhead program is to release 75,000 smolts each year.

Harvest of hatchery-produced summer steelhead is managed to comply with the lower Columbia steelhead DPS FMEP (ODFW 2003), which explains the management implications of holding a recreational fishery where hooking mortality of listed fish may occur (ODFW 2011c). Current fishing regulations in the Lower Columbia River DPS require that all unmarked adult steelhead be released back to the water unharmed (see the evaluation of the FMEP in (NMFS 2003b)). Since 2003, relatively small changes in fisheries management have occurred relative to the assessment by NMFS (2007b); the effect of those refinements will be considered in Section 4, Environmental Consequences. Only adult steelhead with an adipose fin clip may be retained in recreational fisheries targeting winter steelhead in the lower river downstream of the mouth of the Salmon River. The catch of summer steelhead has averaged about 850 adults annually from 2001 to 2009 (ODFW 2011c).

The Sandy River summer steelhead hatchery program proposes to sufficiently isolate hatchery summer steelhead from the natural-origin winter steelhead population. The Sandy River does not have a natural population of summer steelhead. The hatchery program would use summer steelhead derived from the Washougal River (Skamania Hatchery) in Washington State that are propagated at the South Santiam Hatchery (designated Oregon Skamania stock 24) on the South Santiam River in Oregon. Broodstock for this program would not be collected in the Sandy River Basin but from returns to the South Santiam River. Broodstock for the summer steelhead program in the Sandy River are part of the larger production program at the South Santiam Hatchery and not collected specifically to support the Sandy River summer steelhead program. About 2,000 adult hatchery summer steelhead are collected annually at Foster Dam (on the South Santiam River) to meet egg requirements for all summer steelhead (Skamania stock 24) propagation programs operated by ODFW. Broodstock is transferred to the South Santiam Hatchery, which is adjacent to the Foster Dam trap. The South Santiam Hatchery is located at RM 38.5 on the South Santiam River in the Upper Willamette River Basin, Linn County, Oregon. The operation of the Santiam Hatchery was evaluated in a separate ESA consultation and determined not to jeopardize listed salmon and steelhead in the Upper Willamette River Basin (COE and NMFS 2008). The operation of the Santiam Hatchery is not be evaluated as part of this analysis because these facilities would continue to be operated in a similar manner without the addition of the production from the proposed hatchery program.

Adult holding, spawning, and early incubation occurs at the South Santiam Hatchery. Eyed-eggs are then transferred in March to Bonneville Hatchery for egg incubation and early rearing. The summer steelhead at Bonneville Hatchery are reared to a target size of 4.5 fpp and would then be transferred in March to Sandy Hatchery for acclimation and release. All of Sandy Hatchery summer steelhead smolts are fin marked (adipose fin-clip) at Bonneville Hatchery prior to transfer to the Sandy Hatchery. Mitchell Act funds are used to support the production of Sandy River summer steelhead at the Bonneville Hatcheries. These facilities would continue to be operated and funded in a similar manner without the addition of the production from the proposed hatchery program.

The hatchery program would acclimate and release up to 75,000 smolts into Cedar Creek at the Sandy Hatchery (ODFW 2011c; 2013d). The summer steelhead are acclimated for approximately 3 weeks prior to release. Acclimation at the hatchery is expected to lead the fish back to the hatchery, as adults, and reduce the number that escape to spawn naturally. Smolts are transferred, in April, from the raceways to the adult holding pond and allowed to recover for approximately 24 hours prior to release. The fish are then released from the adult holding pond by removing screens and partially lowering the water level in the pond to facilitate a gradual release and dispersed downstream migration of smolts. Fish are allowed to volitionally migrate from the pond for a 24-hour period. After 24 hours water levels in the pond are gradually dropped further to promote migration. After approximately 48 hours, the pond is emptied and any remaining fish enter Cedar Creek. Based on long-term observations, approximately 80 to 90 percent of the steelhead smolts leave volitionally, because they are ready to leave freshwater, during the first 24 hour period after screen removal, and nearly all have left the pond by the end of the 48-hour period.

The pHOS goal for this program is less than 5 percent (based on a 3-year moving average). This pHOS is half the requirement for a hatchery program that is not diverged from the local population and is included in the ESU or DPS. In this case summer steelhead are not endemic to the Sandy River and the hatchery program is not included in the LCR Steelhead DPS (Jones 2011). All hatchery summer steelhead returning to Sandy Hatchery are collected and are either given to a local food bank, recycled to the lower river, or disposed of if not fit for human consumption. Fish that return to Sandy Hatchery prior to August 1 may be recycled once through the lower river fishery to provide additional angling opportunities. Recycled fish are released at Lewis and Clark Park (approximately RM 3.0). All recycled fish are distinctly marked (e.g., caudal punch or Floy tag) prior to release. Fish would only be recycled once; all fish that are collected a second time are permanently removed from the Sandy River. No fish would be recycled to the lower river after July 31. No hatchery summer steelhead collected at tributary weirs/traps will be recycled; these fish would be removed from the Sandy River. Unmarked summer steelhead collected at the tributary weirs/traps would be genetically sampled and released above the weirs. Surplus hatchery summer steelhead may also be relocated to isolated standing waters (e.g., Salish Ponds) to provide additional angling opportunity associated with trout fisheries. Fish that are to be disposed of are done so in accordance with ODFW policies and procedures, which include freezing, rendering, and burying.

2.2. Alternative 2 (No-hatchery) – Do Not Approve the HGMPs under Limit 5 of the 4(d) Rule

Under this alternative, the Secretary would not approve the four HGMPS, likely by determining that the four hatchery programs as described by the HGMPs do not meet the criteria under limit 5 of the 4(d) Rule, and therefore the Secretary would not provide a concurrence letter. NMFS treats disapproval of the HGMPs as resulting in the termination of all hatchery programs as described in the HGMPs (Table 2). It is assumed that terminating the hatchery programs would lead to the adult weir and intake structure at the Sandy Hatchery not being operated to allow voluntary passage up and down Cedar Creek. Terminating these programs may or may not result in the redirection of Mitchell Act funds considered here; ODFW would have the option of reprogramming the funds dedicated to other rearing facilities or continuing to use them as planned. There are a number of other potential outcomes that might result from this determination (e.g., pursue other regulatory mechanisms for ESA authorization, substantially alter the proposed hatchery programs, or rear other species), but the termination of the hatchery programs represents an obvious potential outcome, and it represents one end of the spectrum of potential effects.

This No-hatchery Alternative is consistent with Alternative 2 in the Mitchell Act FEIS, which evaluated a scenario where Mitchell Act-funded hatchery programs would not be funded and thus would not be operated (NMFS 2014b). This FEIS scenario included the Sandy Hatchery programs because at the time that the EIS was being drafted, Sandy Hatchery programs were funded under the Mitchell Act.

2.3. Alternative 3 (Reduced Production Alternative) – Production Limited to Levels that would Achieve Less-than-5 Percent pHOS goal.

Under this alternative, the goal would be to release smolts at levels such that pHOS is less than 5 percent for the returning natural-origin spring Chinook salmon, coho salmon, and winter steelhead populations in the Sandy River Basin (based on a 3-year moving average).

The Mitchell Act FEIS did not have an alternative that would be consistent with the Reduced Production Alternative analyzed in this EA, though it did identify that one measure that could be taken to reduce hatchery impacts on natural-origin salmon and steelhead was reducing the number of smolts released (NMFS 2014b). The reduction in smolt release numbers is a main component of the Reduced Production Alternative.

As discussed below in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, hatchery fish spawning naturally can have genetic effects on the natural-origin population including outbreeding effects and hatchery-influenced selection. Outbreeding effects are caused by gene flow[5] resulting from fish from other populations spawning with fish from the local population. The proportion of fish spawning in the wild represented by hatchery fish or pHOS is often used as a surrogate measure for gene flow. It is important to note that outbreeding effects are a risk when the hatchery fish are derived from a different population than the natural-origin population. If the hatchery fish are from the same population, then the risk is from hatchery-influenced selection (see discussion in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. In a 1999 biological opinion, NMFS determined that some hatchery programs were jeopardizing the existence of ESA listed steelhead and included a Reasonable and Prudent Alternative that stated that for non-indigenous salmon and steelhead, stray rates (in this case pHOS) shall not exceed 5 percent of the annual natural population size in the receiving stream (NMFS 1999). Similar general guidelines have been developed to address these risks, which can vary depending on the type of hatchery program (whether it uses natural-origin fish in the broodstock (i.e., integrated) or whether it uses only returning hatchery adults (i.e., isolated or segregated)) and the conservation goal for the natural-origin population (HSRG 2009c; California HSRG 2012)(Subsection 4.3, Effects on Anadromous Fish Listed under the ESA). The HSRG (2009c), the California HSRG (2012), and HSRG (2014) all recommend that pHOS for segregated hatchery programs be less than 5 percent.

Under the Reduced Production Alternative, the goal is to operate the four hatchery programs as segregated programs such that pHOS is less than 5 percent to minimize the potential for genetic effects on the natural-origin populations. To meet this 5 percent pHOS goal, the Reduced Production Alternative proposes to decrease the spring Chinook salmon smolt release to 90,900; the coho salmon smolt release to 222,000; and the winter steelhead smolt release to 125,000

[5] Gene flow between natural-origin and hatchery-origin fish is often interpreted as meaning actual matings between natural-origin and hatchery-origin fish. However, in this document, unless otherwise specified, gene flow means contributing to the same progeny population. For example, hatchery-origin spawners in the wild will either spawn with other hatchery-origin fish or with natural-origin fish. Natural-origin spawners in the wild will either spawn with other natural-origin fish or with hatchery-origin fish. But all these matings, to the extent they are successful, will generate the next generation of natural-origin fish.

(Table 2). The summer steelhead releases would not change under this alternative because the pHOS goal for summer steelhead is currently below 5 percent.

The smolt release levels were derived from the formula below where X is the calculated smolt release level based on recent pHOS estimates and the smolt releases levels that contributed to that pHOS estimate.

$$X = \frac{(0.05)(\text{number of smolts released that contributed to pHOS estimate})}{(\text{pHOS estimate})}$$

For spring Chinook salmon, the average of the pHOS estimates for 2012 and 2013 (16.5 percent) was used because these pHOS estimates reflect the use of the tributary weirs. Under this alternative the weirs would continue to be used to remove hatchery spring Chinook salmon. The coho salmon smolt release level was derived using the 2013 to 2014 preliminary estimate of 11.3 percent because it is the most recent and it provides a meaningful reduction in the release level relative to the No-action Alternative and the Proposed Action Alternative. The 2013 estimate of pHOS for winter steelhead (6.4 percent) was used for this alternative because the pHOS estimate was based on more intensive monitoring compared to estimates from spawning ground surveys in earlier years, where pHOS estimates ranged from 0 to 28 percent. Ultimately, the purpose of this alternative is to broadly demonstrate the effects of a meaningful reduction in the size of the existing hatchery program, not merely the genetic effects from achieving a reduced pHOS of 5 percent. In drafting this alternative, NMFS chose a point that differs meaningfully from the Proposed Action and the No-hatchery Alternative, and that was recommended by scientific groups (HSRG 2009c; California HSRG 2012). Sizing the program to achieve a 5 percent pHOS is one logical mid-point out of many possibilities; it is not intended to imply what the appropriate pHOS target would be, but to provide a reasonable basis for analysis intermediate between the Proposed Action and the No-hatchery alternative to help illustrate how the effects on the human environment might change over that range of impacts. The smolt release totals used to frame this alternative constitute NMFS' best estimate of how to size the program to achieve a 5 percent pHOS.

Fisheries targeting adults returning from hatchery fish produced under the Reduced Production Alternative would be operated the same as described under the No-action Alternative. The individual hatchery programs under the Reduced Production Alternative would be operated in the same manner as those programs described under the No-action Alternative, the only difference would be in the number of adults needed for broodstock and the number of juveniles released. Monitoring and evaluation activities (i.e., spawning ground surveys, juvenile production in Cedar Creek, and juvenile outmigration sampling) as described under the No-action Alternative would also be conducted under this alternative.

In the Sandy River Basin, pHOS is estimated from data collected during spawning surveys. The abundance of the natural spawning population is estimated, as is the proportion of hatchery-origin fish spawning naturally throughout the geographical and temporal spawning range of the population. The proportion of hatchery-origin fish in the naturally spawning population is estimated by expanding the number of known hatchery fish (based on fin-clips and/or other marks) that are either collected as carcasses (spring Chinook salmon and coho salmon) or

visually observed (steelhead) during spawning ground surveys. Estimated this way, pHOS is purely a demographic metric, and under this alternative will be used to determine if the pHOS goal is being achieved.

2.4. Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule

Under this alternative, the Secretary would approve the four proposed hatchery programs under limit 5 of the 4(d) Rule, and the hatchery programs and associated Best Management Practices BMPs would be implemented as described in the four 2013 HGMPs. For the purpose of this analysis, NMFS treats the Proposed Action Alternative as resulting in the hatchery production of Chinook salmon, coho salmon, and steelhead as proposed in the four HGMPs.

Under the Proposed Action, there are a number of changes to the hatchery programs compared to the No-action Alternative. These changes in the operation of the hatchery programs contributed to NMFS' decision to initiate ESA consultation on these new programs as described in the 2013 HGMPs (ODFW 2013e; 2013d; 2013c; 2013b). These changes are described below for each of the hatchery programs.

The Mitchel Act FEIS Alternative 4 is most similar to the Proposed Action Alternative, specifically, FEIS Alternative 4 assumes that the spring Chinook salmon program would be integrated, and the coho salmon and summer steelhead programs would be operated the same as under the EA Proposed Action Alternative except that the number of smolts produced is smaller for Proposed Action Alternative in this EA than that what was evaluated in FEIS Alternative 4 (500,000 versus 700,000 coho salmon smolts; 75,000 versus 160,000 summer steelhead smolts).

Under FEIS Alternative 4, the winter steelhead program would be operated as a segregated program similar to the No-action Alternative in this EA. Alternative 1 in the FEIS did evaluate an integrated winter steelhead program in the Sandy River Basin that is consistent with the Proposed Action Alternative.

2.4.1. Sandy River Spring Chinook Salmon Hatchery Program

The spring Chinook salmon hatchery program would be operated similarly to the spring Chinook salmon program under the No-action Alternative, the primary differences would be in the initial production goal (Table 2), the incorporation of natural-origin adults into the broodstock, changes in weir operations and rearing locations.

Under the Proposed Action Alternative, to reduce genetic risks, the pHOS goal would continue to be less than 10 percent. To achieve this goal, releases would begin at 132,000 fish annually and would only increase as long as pHOS remains at or below 10 percent, based on a 3-year moving average. Under the Proposed Action Alternative, production would only increase if the effects threshold for pHOS is not exceeded, as opposed to exceeding the threshold while production decreases as under historical BMPs and the No-action Alternative. ODFW proposes to start production at 132,000 smolts, and, based on annual monitoring and evaluation, ODFW proposes to increase releases incrementally, up to a maximum release goal of 300,000 smolts, so long as the 3-year moving average for pHOS remains less than 10 percent. If the 10 percent

pHOS goal cannot be achieved at the increased production level, then smolt releases would be reduced to the level where the pHOS goal was maintained. In this analysis, NMFS will evaluate the effects on the human environment at the minimum and maximum production goals.

As described above under the No-action Alternative, Sandy Hatchery spring Chinook salmon were derived from natural-origin Sandy River spring Chinook salmon and incorporated natural-origin adults into the broodstock until 2011 when only returning Sandy Hatchery spring Chinook salmon were used. Based on this history, NMFS determined that the Sandy Hatchery spring Chinook salmon were part of the ESA-listed LCR Chinook Salmon ESU (Jones 2011). Under the Proposed Action Alternative, ODFW has proposed to achieve an annual pNOB of up to 20 percent to avoid substantial divergence between the hatchery and natural-origin spring Chinook salmon and reduce the threat of genetic effects. ODFW's proposal is to incorporate natural-origin spring Chinook salmon into the broodstock such that 20 percent of the spawners are natural-origin spring Chinook salmon (ODFW 2013b).

To produce up to 132,000 smolts for release, a total of 108 adults are needed for broodstock; out of this total, 22 would be natural-origin, and the remainder would be returning hatchery adults. At a 300,000 smolt production level, a total of 210 adults would be needed for broodstock and, of these, 42 would be natural-origin adults. At no time would more than 2 percent of the natural-origin spring Chinook salmon returning to the Sandy River Basin annually be used for hatchery broodstock. The escapement of natural-origin spring Chinook salmon would be monitored at the weirs to ensure that the spring Chinook salmon escapement is such that broodstock collection would not exceed 2 percent of the natural-origin population. Under the Proposed Action, ODFW would collect and use only natural-origin male spring Chinook salmon to ensure integration of the hatchery program with the natural population. The natural-origin males would be live spawned, and then returned to natural spawning areas in the Sandy River where they can potentially spawn again.

Under the Proposed Action Alternative, the three tributary weirs used to collect and remove hatchery spring Chinook salmon would be operated as described under the No-action Alternative. The weirs are expected to be operated at the same locations that were used in 2013 and 2014. ODFW has increased the estimated number of natural-origin spring Chinook salmon that could be handled at the weirs to 3,080 adults, compared to 2,750 adults under the No-action Alternative, because of the recent increases in abundance (Subsection 3.3, Anadromous Fish Listed Under the ESA). The 3,080 adult estimate includes up to 80 natural-origin spring Chinook salmon that could volunteer into the Sandy Hatchery, which would also be transported to the mainstem Sandy River to spawn naturally.

As under the No-action Alternative (Subsection 2.4.4, Sandy River Summer Steelhead Program), under the Proposed Action, all hatchery summer steelhead encountered at the three tributary weirs would not be recycled to the lower Sandy River, but would be removed to the Sandy Hatchery and would be disposed of as described under the No-action Alternative. Under the Proposed Action Alternative unmarked (no adipose fin-clip) summer steelhead collected at the Salmon and Zigzag River weirs would genetically sampled and transported downstream to Lewis and Clark Park at approximately RM 3 on the mainstem Sandy River. Unmarked summer

steelhead collected at the Bull Run River weir would be genetically sampled and released below the weir.

As stated above, summer steelhead are not endemic to the Sandy River and any unmarked summer steelhead encountered at the weirs could be mis-marked hatchery summer steelhead (i.e., hatchery summer steelhead that escaped being adipose fin-clipped before release), adults returning from naturally spawning hatchery summer steelhead, or strays from outside the Sandy River Basin. The intent of releasing the unmarked summer steelhead in the lower Sandy River is to allow them the opportunity to escape back to the hatchery (mis-marked hatchery fish), or resume their migration up the Columbia River (stray out-of-basin fish). Under the No-action Alternative, these fish would have been released above the weir, and therefore unable to reach lower river or out-of-basin destinations.

Under the Proposed Action Alternative, spring Chinook salmon broodstock would be held and spawned at the Clackamas Hatchery (same as the No-action Alternative), but the green eggs would be taken to Sandy Hatchery where they would be fertilized and incubated to the eyed-egg stage at which time they would be transported to Oxbow Hatchery for final incubation and rearing until they reach a size of 80fpp. After the fish reach a size of 80fpp, they would be transported to nearby Cascade Hatchery and reared to a size of 18fpp. In November, the fish would be returned to the Sandy Hatchery where they would be reared until the following February/March.

Under the Proposed Action Alternative, the Willamette Hatchery and Leaburg Hatchery would not be used for rearing with the goal of maximizing the amount of rearing that can occur within the Sandy River Basin. The operation of the Oxbow and Cascade Hatcheries would not be evaluated as part of this analysis because these facilities would continue to be operated and funded in a similar manner without the addition of the production from the proposed hatchery program.

Under the Proposed Action, hatchery spring Chinook salmon smolts would be adipose fin-clipped and would also receive an internal otolith mark and a CWT. The hatchery spring Chinook salmon smolts would be acclimated and released from the Bull Run Acclimation Pond as described under the No-action Alternative.

2.4.2. Sandy River Coho Salmon Program

The Sandy River coho salmon hatchery program would be operated similarly to the coho salmon program under the No-action Alternative, the primary differences would be in the production goal (Table 2), and a change in the pHOS goal.

Under the Proposed Action Alternative the release goal would be reduced to 300,000 smolts from the 500,000 proposed in the No-action Alternative. This would reduce the number of broodstock needed from the 450 adults (200 to 250 females and 200 to 150 males) under the No-action Alternative to 250 adults (150 females and 100 males) under the Proposed Action Alternative. The coho salmon would be spawned and reared at the Sandy Hatchery through release as described under the No-action Alternative. Rearing the coho salmon from incubation

to release at the Sandy Hatchery is intended to maximize homing back to the hatchery by the returning hatchery adults to minimize the number of hatchery adults that could spawn naturally.

Under the Proposed Action Alternative, the pHOS goal was reduced to less than 5 percent from the less-than-10 percent goal under the No-action Alternative. As described above, the coho salmon program was derived from the natural-origin population in the Sandy River, has only used this stock since its inception in return year 1952-53, and had integrated natural-origin coho salmon into the broodstock. Since 1998, all hatchery coho have been mass marked, and naturally produced coho were no longer incorporated into the broodstock (i.e., pNOB = zero). However, hatchery coho have not substantially diverged from the natural population, are still integrated with the natural population, and the hatchery program is still included in the LCR Coho Salmon ESU (NMFS 2004b; Jones 2011).

Because the coho salmon program does not intend to use local, natural-origin coho salmon for broodstock (pNOB = zero), ODFW has decided to impose a stricter pHOS goal in advance of any divergence between hatchery coho salmon and the natural population. The 3-year moving average pHOS goal for hatchery coho salmon that escape the recreational and commercial fisheries is less than 5 percent.

2.4.3. Sandy River Winter Steelhead Program

The Sandy River winter steelhead hatchery program would be operated similarly to the winter steelhead program under the No-action Alternative, the primary differences would be in the incorporation of natural-origin adults into the broodstock, and how hatchery adult winter steelhead are managed in Cedar Creek above the Sandy Hatchery.

As described under in the No-action Alternative, the Sandy River winter steelhead program is included in the LCR Steelhead DPS. Past analyses by NMFS has shown that the Sandy Hatchery winter steelhead program had minimal divergence from the natural population, and that it had regular and substantial incorporation of natural origin fish into the hatchery broodstock and as a result was included as part of the DPS (NMFS 2004b). In the 5-year status review, the best available scientific information continued to support these determinations (Jones 2011). Under the Proposed Action Alternative, ODFW proposes to maintain the integration of the Sandy Hatchery program and the Sandy River natural-origin winter steelhead population by including up to 26 natural-origin male winter steelhead in the broodstock annually (a pNOB of approximately 20 percent). The number collected would be limited such than no more than 2 percent of the natural-origin adult winter steelhead returning to the Sandy River would be retained for broodstock. The escapement of natural-origin winter steelhead would be monitored during winter steelhead spawning surveys to ensure that the winter steelhead escapement is such that broodstock collection would not exceed 2 percent of the natural-origin population. The natural-origin males would be live spawned and then returned to natural spawning areas in the Sandy River where they can potentially spawn again.

Under the No-action Alternative, hatchery winter steelhead could be passed upstream of the hatchery weir in Cedar Creek to spawn naturally, under the Proposed Action Alternative, only unmarked winter steelhead would be released above the Sandy Hatchery. ODFW would evaluate the abundance, productivity, and spatial distribution of winter steelhead upstream of the weir at

the Sandy Hatchery through an assessment of the counts of natural-origin adult fish passed upstream to spawn and juvenile counts from a smolt trap located above the Sandy Fish Hatchery. After 5 years (return year 2019), if it is found that hatchery supplementation would likely result in a net benefit to natural population abundance, productivity, diversity, and spatial distribution, ODFW would submit a proposal to NMFS for a supplementing the natural-origin population in Cedar Creek with returning hatchery winter steelhead.

2.4.4. Sandy River Summer Steelhead Program

There are no changes relative to the Sandy River Summer Steelhead Program described under the No-action Alternative.

2.5. Alternatives Considered but Not Analyzed in Detail

Alternatives that would consider increases or decreases in hatchery production levels, or changes in BMPs, were considered, but determined to be less likely to provide the intended benefit of providing fishing opportunities while conserving and enhancing the natural-origin populations. Consequently, these potential alternatives were considered to not meet the purpose and need for the Proposed Action, or would not provide an analysis that differs from the analyses under the No-action Alternative or action alternatives.

- The Secretary would determine that the four proposed hatchery programs, as described in the HGMPs, meet the criteria for section 10(a)(1)(A) permits. Under this alternative, the only change from the Proposed Action would be a difference in ESA authorization for these hatchery programs. The analysis of impacts under this alternative would not differ from the analysis that would occur under the Proposed Action.
- Best Management Practices (BMPs) – Under this alternative, the Secretary would approve the four proposed hatchery programs under limit 5 of the 4(d) rule, and the hatchery programs would be implemented as described in the 2013 HGMPs. However, under this alternative, additional BMPs not necessarily applied to all HGMPs under the Proposed Action Alternative would be applied to reduce adverse impacts of the hatchery programs on natural-origin salmon and steelhead populations.

  This alternative is not reasonable because any additional BMPs that are not already proposed under the Proposed Action Alternative (as described in the 2013 HGMPs (ODFW 2013e; 2013d; 2013c; 2013b)) would provide little or no additional benefit to the listed species because the proposed 2013 HGMPs have already implemented reforms that include BMPs considered necessary and appropriate for the proposed hatchery programs. Such BMP implementation has been analyzed under Alternative 4 as the Proposed Action.
- Greater levels of hatchery production than those proposed – NMFS could have considered production levels greater than proposed in the four HGMPs. However, higher production levels would exceed the capacity of the production facilities and could potentially reduce the survival of the artificially propagated fish and, thus, would not meet the purpose and need.

3. AFFECTED ENVIRONMENT

3.1. Introduction

The four alternatives considered in this EA can potentially affect the physical, biological, social, and economic resources within the action area. Below is a description of the baseline condition of the environmental resources that would be affected by these alternatives

3.2. Water Quality and Water Quantity

Habitat conditions important to the various ESA-listed salmonids in the action area vary widely; however, factors such as water quality and water quantity (i.e., flow conditions) are important to most fish species in the action area. Salmonids and other native fish species depend on good water quality for migration, spawning, rearing, and overall viability (C. et al. 1995). Salmonids, in particular, require clear, cold waters for optimal health (C. et al. 1995). Water temperature is a key factor affecting salmonid spawning and rearing in some areas of the Sandy River Basin; other water quality parameters that are important to salmonids include turbidity, dissolved oxygen, and availability of nutrients (C. et al. 1995).

By authorities delegated by the Environmental Protection Agency (EPA), the Oregon Department of Environmental Quality (ODEQ) manages the quality of Oregon's streams, lakes, estuaries, and groundwater. ODEQ developed a Water Quality Management Plan (Oregon Department of Environmental Quality 2006) that provides a strategy for (1) reducing discharges from non-point sources to the required "load allocations," and (2) reducing discharges from point sources to the required "waste load allocations" described in the total maximum daily load plan for the Sandy River (Oregon Department of Environmental Quality 2006). ODEQ has the authority to manage effluent from hatchery facilities through NPDES permits (Oregon Department of Environmental Quality 2007). As described above, ODFW operates the Sandy River Hatchery under a NPDES permit. Under section 303(d) of the Clean Water Act, ODEQ developed a list of "impaired waters" for the Sandy River Basin (Table 3). The two temperature criteria that were exceeded for the water bodies in Table 3 are related to salmon and steelhead spawning (a 7-day average maximum of 55.4ºF (13.0ºC) from August 15 to June 15) and to salmon and steelhead rearing and migration (a 7-day average maximum of 64.4ºF (18.0ºC) all year-around (during non-spawning periods)).

Table 3. Water bodies in the Sandy River Basin listed under section 303(d) of the Clean Water Act (Oregon Department of Environmental Quality 2006).

Water Body	303(d) Listing Parameter	Year Listed	River Mile
Alder Creek	Temperature	2004	0 – 2.0
Badger Creek	Temperature	2004	0 – 6.0
Beaver Creek	Temperature	2004	0 – 8.4
Blaze Alder Creek	Temperature	2004	0 – 3.9
Boulder Creek	Temperature	2004	0 – 5.7
Bull Run River	Temperature	2004	0 – 26.9
Cedar Creek	Temperature	2004	0 – 14.2
Clear Creek	Temperature	2004	0 – 0.7
Little Sandy Creek	Temperature	2004	0 – 15.7
Salmon River	Temperature	2004	0 – 33.9
Sandy River	Temperature	2004	0 – 55.5
South Fork Salmon	Temperature	2004	0 – 1.4
Still Creek	Temperature	2004	0 – 6.2
Zigzag River	Temperature	2004	0 – 6.9

The ODFW, as part of the NPDES permit requirements, monitored effluent temperature for a period of 3 years to determine compliance with Oregon's water quality (temperature) criteria set for the Sandy River Basin. After the 3-year period, ODFW prepared the impact analysis that was submitted to the ODEQ (Oregon Department of Environmental Quality 2006). The analysis determined that the maximum instantaneous temperature of the hatchery effluent never reached the maximum limit in the NPDES permit of 77ºF (25ºC) during the 3-year period (2003-2005). During the spawning period (October 15 – May 15), water temperatures at the mixing zone exceeded 55.4ºF (13.0ºC) on two occasions – 58.5ºF (14.7ºC) on October 20, 2003, and 57.6ºF (14.2ºC) on May 4, 2003 – but the ambient water temperatures of the stream were also the same, and the hatchery effluent did not add any thermal load to the mixing zone on these dates (Tables 1 and 2 in (Oregon Department of Environmental Quality 2006).

During the salmon and steelhead rearing and migration period, ODFW observed that water temperatures in the mixing zones exceeded 64.4ºF (18.0ºC) during July and August of 2003, but hatchery effluent did not increase the ambient temperatures of the receiving stream. In August 2004, ODFW measured a maximum thermal load of 0.2ºF (0.1ºC) at the mixing zone of the receiving stream. ODFW observed that there were no differences in water temperatures between the hatchery outfall and Cedar Creek's ambient temperatures during July and August 2004, and that the 0.2ºF (0.1ºC) temperature load may have been due to sampling error (Oregon Department of Environmental Quality 2006). ODEQ determined that the hatchery effluent did not add to the thermal load on Cedar Creek (Oregon Department of Environmental Quality 2006).

The NPDES permit sets limits on total suspended solids, settleable solids, temperature, and pH for hatchery effluent (Oregon Department of Environmental Quality 2006). When fish are being reared at the Sandy Hatchery, total suspended solids and settleable solids (which contribute to turbidity) are controlled by passing the hatchery effluent through a pollution abatement pond to settle out un-eaten foods and fish wastes. The NPDES requires monthly monitoring of total

dissolved solids and settleable solids as well as pH. Measurements are taken during normal operations and during pond cleaning activities. ODEQ did not identify low dissolved oxygen as contributing to the impairment of the waters in the Sandy River Basin (Oregon Department of Environmental Quality 2006), and direct management of dissolved oxygen levels is not required under the NPDES permit. Dissolved oxygen levels in the hatchery effluent are restored to ambient levels due to mixing of the hatchery effluent water and water in the adult fish ladder prior to release into Cedar Creek. The hatchery effluent may contain aquaculture drugs and chemicals (formalin); however, under current operations these are strictly monitored and are prescribed by licensed veterinarians to be effective in the treatment of the fish pathogen while meeting drug label criteria for environmental exposure. The location of the settlement pond is out of the Sandy River flood plain and high enough that it has never been impacted by flooding in Cedar Creek (ODFW 2013a).

During the spring, when acclimating and releasing juvenile fish on station, the hatchery removes up to 11,200 gpm (out of ODFW's 12,577 gpm water right). Prior to 2013, when the Sandy Hatchery was operated year-around and especially during the summer low flow periods, the section of Cedar Creek from the intake downstream to the outfall, a distance of approximately 900 feet would become dewatered (i.e., no flow). This would impede migration of, and adversely impact, any juvenile fish present in the dewatered section from the intake downstream to the hatchery outfall. When the facility was operated in this manner, adult salmon and steelhead were not passed above the hatchery.

Juvenile fish migrating in Cedar Creek in the section would be impacted by the intake structure blocking upstream passage and by impingement on the intake screens, which previously did not meet NMFS screening criteria (NMFS 2011a). The intake structure was upgraded in 2012 to meet NMFS screening and passage criteria. As described above (Subsection 2.1.2, Sandy River Coho Salmon Program) the minimum amount of water needed for rearing the coho salmon on station (that is, at the hatchery) would be 2,200 gpm in August and 2,300 gpm in September. Flows in Cedar Creek are expected to exceed 3,600 gpm, 95 percent of the time, but low flows can occur during the late summer and early fall (primarily September). This is the critical period when flows in Cedar Creek tend to be at their lowest. During this period, minimum flows will be between 1,300 and 1,400 gpm in the section of Cedar Creek between the hatchery intake to the hatchery outfall (i.e., bypass reach). This level of flow would provide for juvenile rearing and passage flows but is less than the approximately 2,245 gpm (5 cfs) that would be needed to provide adult passage through the bypass reach (ODFW 2013c). Meeting minimum flows in this section during September may limit the ability to rear all of the coho salmon production on station.

The Bull Run acclimation pond would pump up to 600 gpm from the Bull Run River during the period from February through April when spring Chinook salmon are acclimated prior to release. The water pumped from the Bull Run River would be passed through the acclimation pond and released back into the Bull Run River into the same pool from which the water was removed and thus would reduce flows in that section of the river except for a very brief period when the acclimation pond is being filled.

The transport of marine nutrients to freshwater environments by returning anadromous fish has implications for the biology of fish, wildlife, and riparian systems, but can also be considered in terms of effects on water quality. Returning hatchery salmon can provide marine-derived nutrients to freshwater spawning and rearing areas. Gresh et al. (2000) estimated that only 6 to 7 percent of the marine-derived nitrogen and phosphorus that was delivered to the rivers of the Pacific Northwest by spawning salmon 140 years ago is currently returning to those streams. They attributed the loss to habitat destruction due to beaver trapping, logging, irrigation, grazing, pollution, dams, urban and industrial development, and commercial and recreational fishing. (Bilby et al. 2002) found a positive linear relationship between the biomass of juvenile anadromous salmonids and the abundance of carcass material at sites in the Salmon and John Day Rivers, suggesting that spawning salmon may be influencing aquatic productivity and the availability of food for rearing fishes.

Salmon carcasses also appear to promote the growth of riparian forests, a source of large woody debris and stream shading. Helfield and Naiman (2001) hypothesized that there were several pathways for the transfer of marine-derived nutrients from streams to riparian vegetation, including the transfer of dissolved nutrients from decomposing carcasses into shallow subsurface flow paths and the dissemination in feces, urine, and partially-eaten carcasses by bears and other salmon-eating fauna. Studies from the mid-1990s to the early 2000s suggest that the biomass of carcasses affects the productivity of salmonids and salmonid rearing habitat, but functional and quantitative relationships are poorly understood and difficult to generalize from the specific conditions studied (Bilby et al. 1998; Cederholm et al. 1999; Gresh et al. 2000). Limiting factors, and thus the ecological importance of marine-derived nutrients, differ among streams. ODFW outplants excess hatchery salmon carcasses to enhance marine-derived nutrients in the Sandy River Basin. ODFW limits use of carcasses from outside the Sandy River Basin due to disease concerns and high demand for carcasses to support nutrient enhancement activities in other areas.

Human activity such as beaver trapping, logging, irrigation, grazing, pollution, dams, and urban and industrial development have all contributed to a decline in water quality parameters in the action area. Other human activities unrelated to hatchery programs that could affect water quality in the action area include agricultural practices, logging, irrigation, pollution, dams, and urban and industrial development.

3.3. Anadromous Fish Listed Under the ESA

Since 1991, NMFS has identified 12 ESUs and DPSs of Columbia River Basin salmon and Columbia River Basin steelhead as requiring protection under the ESA. Four of the listed anadromous salmonid species originate in the Sandy River Basin (Table 1). In addition to the four salmonid species, NMFS has also listed as threatened under the ESA the Pacific Eulachon (*Thaleichthys pacificus*), which is present in the Sandy River Basin (Table 1).

Under the ESA, NMFS' ultimate goal is the recovery of the listed ESU/DPS such that it no longer needs protections under the ESA. The LCR Salmon and Steelhead Recovery Plan (NMFS 2013c) identifies the criteria necessary to determine when the ESA-listed species can be considered recovered. The recovery of an ESU or DPS to viability is dependent on the recovery of the populations within that listed ESU or DPS. A wide variety of tools can be used to protect

salmonid populations during recovery, including hatcheries, but the ESA standard for bringing a species (ESU or DPS) to the level at which it no longer requires protection depends upon natural-origin fish.

In the LCR, independent populations fall into larger groups based on ecological preference and dominate life history strategy and expressed run timing, meaning the time of year when the salmon or steelhead return to spawn. These major population groups, or strata, share similar genetic characteristics, geographic distribution, and habitat requirements. Strata are largely isolated from one another over a longer time scale than that defining individual populations, but they retain a degree of connectivity greater than that between different ESUs or DPSs. Figure 2 illustrates the relationship between ESU/DPS, strata, and independent populations. In the case of LCR salmon and steelhead, strata are defined by a combination of ecological zone – Coast, Cascade, or Gorge – and dominate life history strategy, such as spring, fall, or late fall run timing. For example, Cascade fall Chinook salmon and Cascade spring Chinook salmon are separate strata.

The Lower Columbia River Recovery Plan identifies what is necessary for a viable ESU/DPS (NMFS 2013c):

- Every stratum should have a high probability of persistence.
- Within each stratum, there should be at least two populations that have at least a 95 percent probability of persistence over a 100-year time frame.
- Within each stratum, the average viability of the populations should be 2.25 or higher, using the McElhany et al. (2007) scoring system (see discussion below) (Table 4). Functionally, this is equivalent to half of the populations in the stratum being viable; a viable population is one whose probability of persistence is high or very high.
- Populations targeted for viability should include those within the ESU that historically were the most productive (“core” populations) and those that best represent the historical genetic diversity of the ESU (“genetic legacy” populations). In addition, viable populations should be geographically dispersed in a way that protects against the effects
- Viable populations should meet specific criteria for abundance, productivity, spatial structure, and diversity.

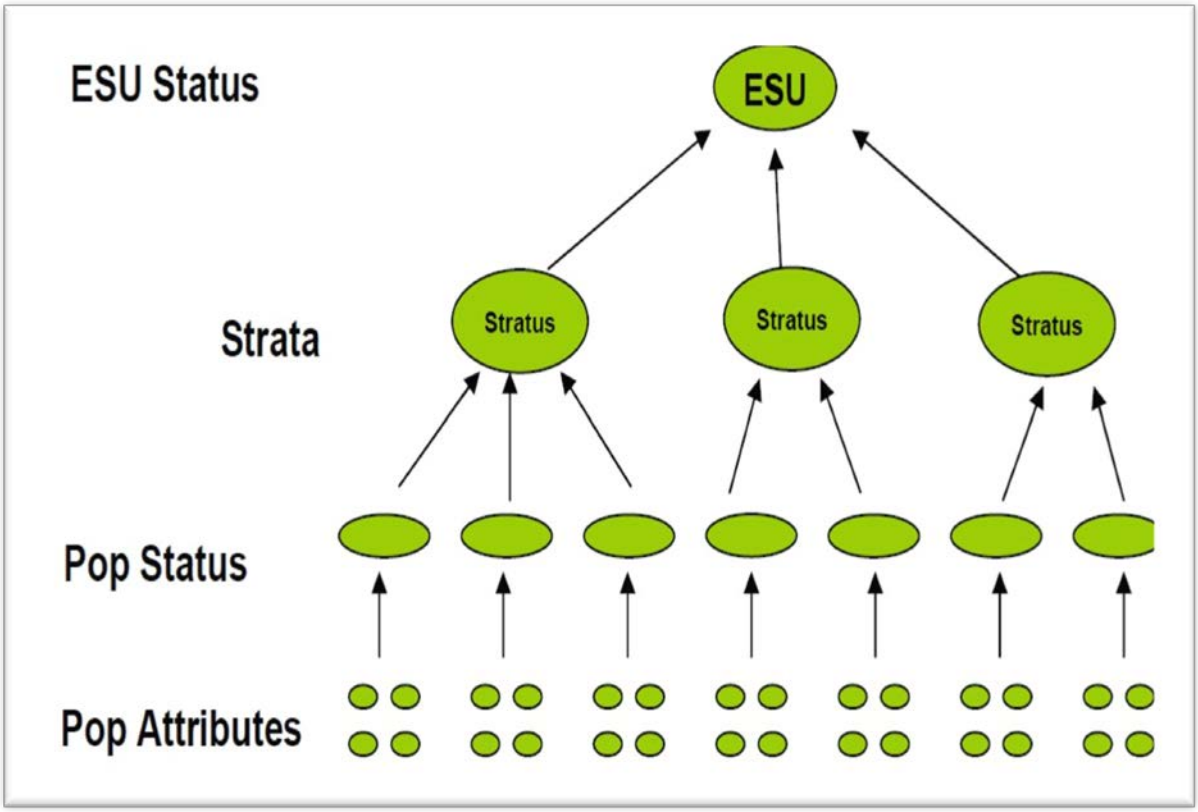

Figure 2. Hierarchical approach for ESU/DPS viability criteria.

Table 4. Population persistence categories (McElhany et al. 2007).

Population persistence category	Probability of population persistence in 100 years (%)	Probability of population extinction in 100 years (%)	Description
0	0 to 40	60 to100	Either extinct or very high risk of extinction.
1	40 to 75	25 to 60	Relatively high risk of extinction in 100 years.
2	75 to 95	5 to 25	Moderate risk of extinction in 100 years.
3	95 to 99	1 to 5	Low (“negligible”) risk of extinction in 100 years (viable salmonid population).
4	Greater then 99	Lower than 1	Very low risk of extinction in 100 years.

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: abundance, productivity, spatial structure, and diversity (e.g., Population Attributes in Figure 2)(McElhany et al. 2000). These viable salmonid population (VSP) parameters, therefore, encompass the species’ “reproduction, numbers, or distribution” as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population’s capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species’ entire life cycle, and

these characteristics, in turn, are influenced by habitat and other environmental conditions. Each parameter is defined below.

- Abundance generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds).
- Productivity, as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults produced per their naturally spawning parental pair. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining.
- Spatial structure refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends fundamentally on habitat quality and spatial configuration and the dynamics and dispersal characteristics of individuals in the population.
- Diversity refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany et al. 2000).

In determining the status of individual populations that make up an ESA-listed species, McElhany et al. (2007) evaluated these four parameters and developed a persistence score for each given population, which corresponds to the persistence categories in Table 4. A persistence score of 2.5, for example, indicates that the population is at moderate risk of extinction in the next 100 years (i.e., 5 to 25 percent probability of extinction). A score of 3 or greater indicates a low risk of extinction, or a 1 to 5 percent probability. As described above, the persistence scores of the individual populations are combined to determine the recovery status of the relative strata, which are then used to determine the status of the whole ESU or DPS.

The current status of each of the listed species in the action area is described below.

3.3.1. Sandy River Spring Chinook Salmon

The Sandy River spring Chinook salmon population is part of the LCR Chinook Salmon ESU. The LCR Chinook Salmon ESU is characterized by numerous short- and medium-length rivers that drain the coast range and the west slope of the Cascade Mountains. Myers et al. (2003) identified 31 historical populations within the ESU (Figure 3 and Figure 4) and estimated that of these populations, 8 to10 have been extirpated, most of these being spring Chinook salmon. The ESU now includes all naturally spawning Chinook salmon from the mouth of the Columbia River to the crest of the Cascade Range, including the White Salmon River in Washington and the Hood River in Oregon (Figure 3 and **Error! Reference source not found.**). The ESU excludes populations above Willamette Falls. The Cowlitz, Kalama, Lewis, Washougal, and White Salmon Rivers constitute the major systems in Washington; the lower Willamette, Hood, and Sandy Rivers are the major systems in Oregon (BRT 2003). NMFS determined that 17 Chinook salmon hatchery programs were part of the LCR Chinook Salmon ESU, including the Sandy River hatchery spring Chinook salmon program (NMFS 2003a; 2004b; Ford 2011). The Sandy River hatchery program is not substantially diverged from the Sandy River spring Chinook salmon natural population. The scientific basis for this determination is provided in NMFS (2003a), NMFS (2004b), and Jones (2011) and, therefore, NMFS considers the hatchery

program to be integrated with the natural population. Populations outside the action area would not be affected by the alternatives, so the Sandy River population is that only population considered in this assessment.

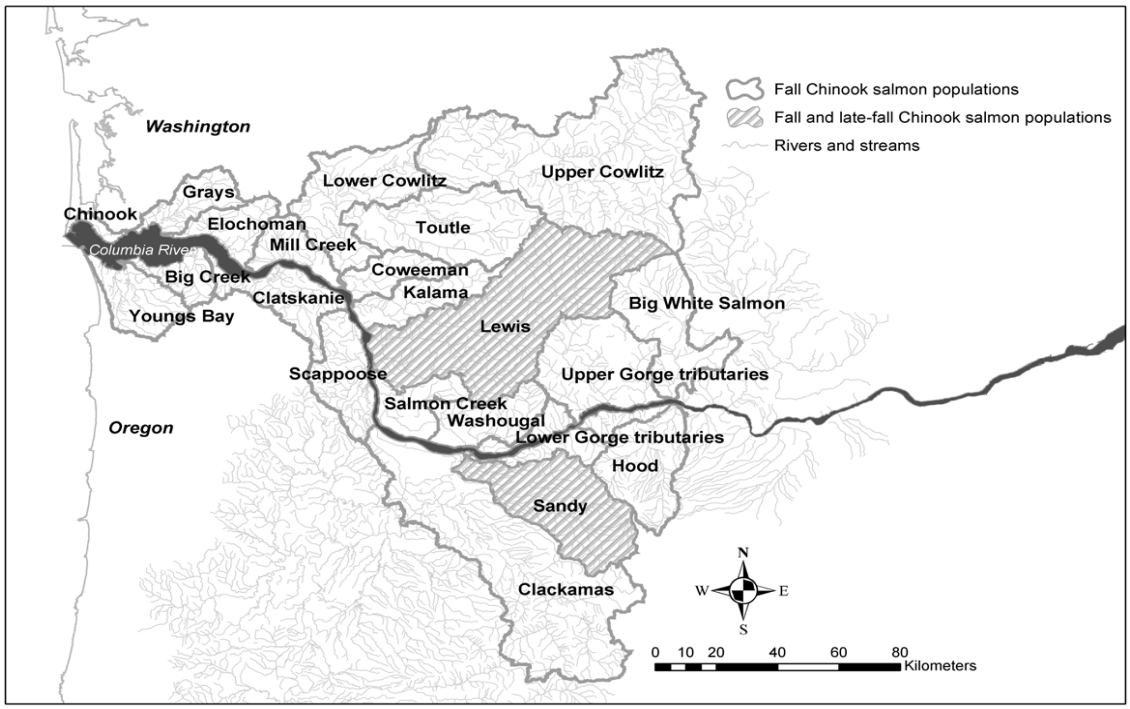

Figure 3. Historical independent LCR early and late fall Chinook salmon populations (Myers et al. 2006).

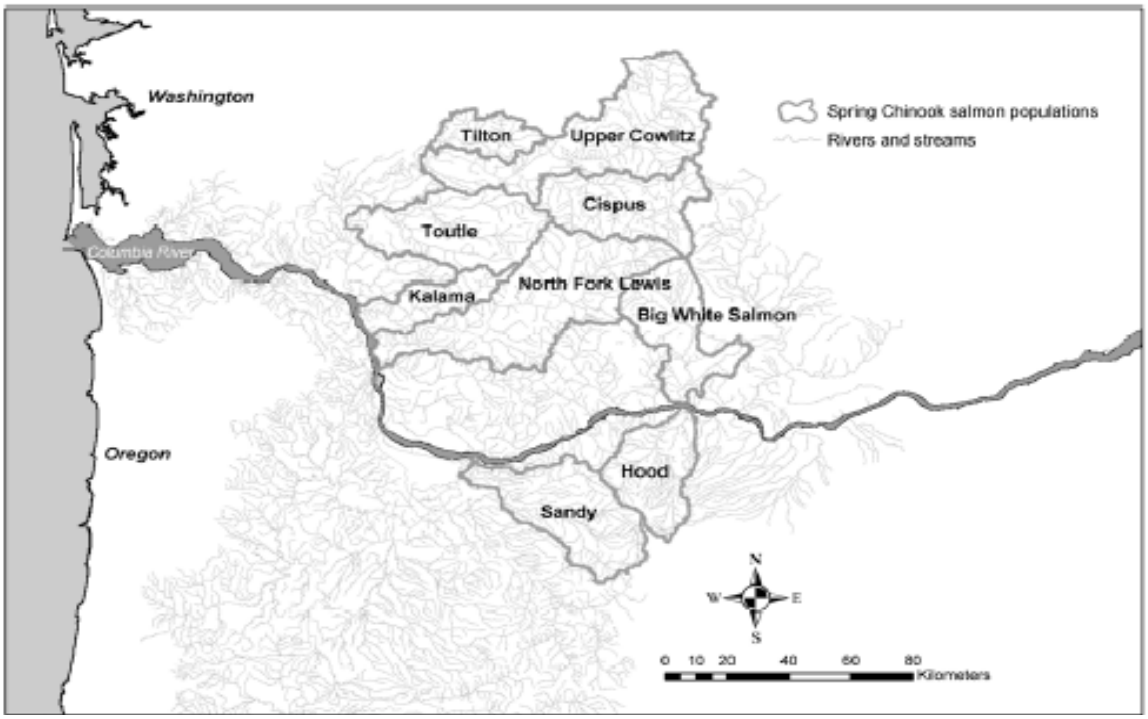

Figure 4. Historical independent LCR spring Chinook salmon populations (Myers et al. 2006).

3.3.1.1. Life History

There are three different runs or types (i.e., populations) of Chinook salmon included in the LCR Chinook Salmon ESU: spring, late fall brights, and early fall tules; the Sandy River Basin supports all three types.

Spring Chinook salmon in the Sandy River tend, as juveniles, to have an ocean distribution that takes them far from the coast; as adults, they enter freshwater in March and April, well in advance of spawning in August and September. Historically, fish migrations were synchronized with periods of high rainfall or snow melt to provide access to upper reaches of most tributaries where spring stocks would hold until spawning (Fulton 1968; Olsen et al. 1992; WDF and WDW 1993).

Typical of the general fall Chinook salmon life history type, tule and bright fall Chinook returning to the Sandy River exhibit more northerly ocean migration patterns than spring Chinook salmon, with bright fish tending to travel farther north than the tule stocks; the fall Chinook salmon enter freshwater in a more advanced stage of sexual maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of their natal rivers, and spawn within a few days or weeks of freshwater entry (Fulton 1968; Healey 1991). Tule fall Chinook salmon begin entering the Columbia River in August, rapidly moving into the lower Columbia River tributaries to begin spawning in September and October. Bright fall Chinook salmon enter the Columbia River over a longer period of time beginning in August and do not begin spawning until October with spawning observed into the following March in some locations. All lower Columbia River Chinook salmon mature from 2 to 6 years of age, primarily returning as 3- and 4-year-old adults (Myers et al. 1998).

Recent escapement estimates for Sandy River spring Chinook salmon have averaged 1,757 over the last 10 years (2004-2013) and ranged from 1,349 to 6,076 adults, and are showing an increasing trend as described in Table 5, below. The variability in escapement estimates are the result of variable conditions that affect the survival of Sandy River spring Chinook salmon from spawning and rearing in freshwater through migration to the ocean and back to the basin.

3.3.1.2. Status and Trends

Ford (2011) recently updated the status review completed in 2005 (Good et al. 2005), concluding that the ESU as a whole is currently at very high risk of extinction. The Sandy spring Chinook salmon population, however, without a mainstem dam, is considered at moderate risk and is the only spring Chinook salmon population in the ESU not considered extirpated or nearly so (ODFW 2010a). The Sandy River late fall (bright) population is one of only two populations in the ESU considered to be at low or very low risk (LCFRB 2010; ODFW 2010a). It contains relatively few hatchery fish and has maintained high spawner abundances since the last Biological Review Team (BRT) evaluation (LCFRB 2010; ODFW 2010a). The tule fall Chinook salmon population is considered to be at very high risk (ODFW 2010a).

Table 5. Total numbers of salmon and steelhead counted at Marmot Dam (Sandy River), 1992-2007, and estimated from spawning ground surveys (2008-2012)(ODFW 2013b). 2014 Spring Chinook salmon estimate is preliminary.

Run	Spring Chinook[a/]		Coho [a/d]		Winter Steelhead [a/]		Summer Steelhead [a/]	
Year	Total [c/]	Wild [b/]	Total [c/]	Wild [b/]	Total[c/]	Wild[b/]	Total [c/]	No Mark
1992	4,451	1,255	790	790	2,916	2,563	2,914	
1993	3,429	967	193	193	1,636	1,438	1,865	
1994	2,309	653	601	601	1,567	1,377	1,979	
1995	1,503	418	697	697	1,680	1,477	1,313	
1996	2,561	697	179	179	1,287	1,131	1,164	
1997	3,301	935	116	116	1,426	1,253	1,859	
1998	2,612	700	261	261	745	655	837	
1999	2,032	581	162	162	928	755	681	20
2000	1,986	564	742	730	784	741	173	110
2001	2,445	988	1,176	1,176	974	902	723	262
2002	1,262	1,035	367	367	1,529	1,031	544	473
2003	1,197	1,053	1,348	1,348	692	671	278	230
2004	2,698	2,294	1,209	1,209	877	869	403	343
2005	1,653	1,405	856	856	632	626	148	128
2006	1,349	1,209	923	923	651	643	126	107
2007	1,410	1,304	753	687	858	845	162	138
2008	4,965	2,721	1,277	1,277	n/a	n/a	n/a	n/a
2009	1,821	856	1,667	1,493	n/a	n/a	n/a	n/a
2010	6,076	1,391	1,029	901	2,096	1,498	n/a	n/a
2011	3,434	1,150	3,813	3,494	681	681	n/a	n/a
2012	4,024	3,070	1,198	1,165	508	508	n/a	n/a
2013	2,395	2,172	756	667	3,747	3,509	n/a	n/a
2014	1,653	1,491			3,316	3,217	n/a	n/a

[a/] Spring Chinook were not 100 percent marked until the 1997 brood year (2000 -2002 adult return years). Coho were not mass marked until the 1996 brood year (1999-2000 adult returns). Summer and winter steelhead have been 100 percent marked since 1996.

[b/] 1992-1998 estimate of wild fish from LCRCRP (ODFW 2010a). Wild fish count prior to 2008 does not include unmarked fish found below the former Marmot Dam.

[c/] Hatchery fish identified by adipose fin-clip were removed from the system beginning in 1998. Count corrected for estimated proportion of unmarked hatchery fish found upstream of the former Marmot Dam.

[d/] Coho salmon totals do not include wild fish released above the Sandy Hatchery into Cedar Creek that began with return year 2010.

The recovery plan for LCR salmon and steelhead (ODFW 2010a) identified similar limiting factors as McElhany et al. (2007) for the Sandy River spring Chinook salmon population including reduced habitat complexity and diversity; access to off-channel habitats; impacts on the estuary habitat from hydropower system operations; and stray hatchery fish interbreeding with natural-origin adults. All of these were considered as the primary factors limiting Sandy River salmon and steelhead recovery.

The recovery goal for the Sandy River population of spring Chinook salmon, as described in Oregon's recovery plan (ODFW 2010a), is for the population to be at low risk of extinction (less than 5 percent probability or a persistence score of 3 (Table 4)[6], with an annual abundance of at least 1,230 natural-origin adults. The Recovery Plan provides specific recommendations specifically for operating the spring Chinook salmon program at Sandy Hatchery (Table 9-3 of the Recovery Plan) (ODFW 2010a). In addition, the table also includes more general recommendations that can be applied to hatchery programs ESU-wide, and most of the actions are designed to achieve a pHOS, averaged over 9 years, of less than 10 percent (ODFW 2010a).

In the NMFS' LCR Recovery Plan (NMFS 2013c), the Sandy River spring Chinook salmon population was identified as a core and genetic legacy population with a recovery target of high probability of persistence (i.e., a persistence score of 3), identifying it as key to the recovery of the Cascade Spring Chinook salmon stratum, and the LCR Chinook Salmon ESU as a whole.

The Sandy River Working Group (SRBP 2005), identified anchor habitats for salmon and steelhead in the Sandy River. Anchor habitats were defined as distinct stream reaches that currently harbor specific life history stages of salmon and steelhead to a greater extent than the stream system at large. Two reaches within the mainstem Sandy River, from approximately RM 24 (2 miles above the mouth of Cedar Creek) to the Salmon River confluence, were identified as anchor habitat. Other identified anchor habitats were all in the mainstem Salmon River up to Final Falls (RM 14), the Sandy River from the Salmon River confluence to the Zigzag River, the lower end of Clear Fork Creek in the upper Sandy River, and the lower end of Still Creek (downstream of Cool Creek) (Figure 1). Spring Chinook salmon spawn primarily upstream of the old Marmot Dam site, with most spawning occurring in the Salmon River up to Final Falls and in Still Creek from its confluence upstream about 3 miles. Spawning also occurs in the Zigzag River, the upper Sandy River (mostly above Clear Creek), and in the lower reaches of Clear Creek and Lost Creek. Spawning has also been observed in the lower Bull Run River (NMFS 2008b).

The action area includes areas designated as critical habitat for LCR Chinook salmon (70 FR 52630). Stream reaches that were accessible to anadromous salmon were designated as critical habitat in 2005 (Table 1). The habitat in Cedar Creek above the Sandy Hatchery and those areas above the dams on the Bull Run River were excluded. NMFS, in designating critical habitat, identified primary constituent elements (PCEs) that consist of the physical and biological features identified as essential to the conservation of the listed species (70 FR 52630). PCEs for salmon and steelhead include sites essential to support one or more life stages of the ESU/DPS (sites for spawning, rearing, migration, and foraging). These sites in turn contain physical or biological features essential to the conservation of the ESU. Those specific types of sites and the features associated with them that are found in the action area include:

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

[6] A persistence score equates to the probability of population extinction provided by the persistence "categories" 0 through 4 developed by McElhany et al. (2007) and described in Table 4.

- 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;
- 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.

3.3.1.3. Limiting Factors and Threats

Viability parameters and designated critical habitat in the Action Area have been affected by a number of factors over the course of many decades. This has largely been a consequence of the natural processes occurring in the basin as they interact with development and management activities that were implemented without adequate consideration or understanding for their effects. The Recovery Plan (ODFW 2010a) identified the key limiting factors for Sandy River Chinook salmon as including:

- reduced habitat complexity and diversity,
- access to off-channel habitats,
- impacts on the estuary habitat from the Federal hydropower system operations, and
- stray hatchery fish interbreeding with natural-origin adults

These key limiting factors may also be affected in the future by climate change, which would be expected to impact natural processes in the action area. These impacts are analyzed in Subsection 5.4. Climate Change. There are many factors in the Columbia River mainstem, the near-ocean environment, and the open ocean that have substantial effects on the survival of salmon and steelhead; all these areas are outside the action area.

Resource Development

Originating from glaciers on the western slopes of Mount Hood in the Cascade Mountains, the Sandy River travels 56 miles before flowing into the Columbia River near the city of Troutdale at Columbia RM 120.5 (Figure 1). The Sandy River drops sharply in the first 13 miles, from elevations of 6,200 to 1,600 feet. The river's gradient exceeds 1,000 feet per mile in several places. The upper Sandy River and several tributaries, including the upper Zigzag and Salmon Rivers, carve through miles of unstable volcanic ash and rock deposits before reaching less steep ground (Taylor 1998).

The headwaters of the Sandy River form on the slopes of Mount Hood, and the upper one-third of the basin is steep, while the middle third of the basin is characterized by a series of alternating terraces and steep, narrow canyons, and the lower basin forms a wide, sandy delta that gives the river its name. Taylor (1998) noted that stream morphology is partially dictated by the composition of geologic material with harder materials, such as basalts, forming confined streams (i.e., limited channel migration), whereas glacial deposits and similar materials give rise

to unconfined streams, an important consideration when assessing fish habitat. Recent changes such as a "large-scale, lahar-related sediment release [that] was observed [in June 2002], likely caused by rapid snowmelt, dramatically increased turbidity levels throughout the Sandy River" (SRBP 2005). These natural conditions and episodic events have consequences for fish habitat and fish productivity.

The SRBP (2005) further describe effects from significant erosion events as:

> . . . [ranging from] high turbidity episodes or siltation of spawning gravels to the loss of riparian cover and alteration of stream morphology. These factors all affect fish habitat. . . . For example, a stream reach surrounded by highly erodible soil covered by mature trees in a protected wilderness area is likely less threatened by erosion than is a stream reach surrounded by moderately erodible soil in an area with a number of active logging roads. Sedimentation concerns exist in several parts of the drainage, especially in those areas that contain unstable and easily erodible soils. . . . Hillslope and channel erosion in some tributaries in the steeply sloping upper reaches of the basin (e.g., Zigzag River drainages) has been attributed to mass wasting and debris torrents (USFS 1996). Such erosion is generally attributed to timber harvest, fire burn, and road construction.

As described above, changes in habitat can affect a number of VSP parameters including spatial structure and diversity (through anthropogenic mortality and habitat diversity elements), and productivity and abundance affected by habitat quality. Natural populations of salmon and steelhead in the Sandy River Basin have been much reduced because of human activities. Timber production has been a predominant commercial activity in the Sandy River Basin, with many effects on terrestrial and aquatic habitats. Timber harvest, and associated sawdust and mill waste impacted water quality, road construction changed surface water runoff patterns increased soil erosion and degraded spawning substrates, and culverts blocked fish passage. Timber harvest continues today, but current harvest and forest regeneration techniques are greatly improved to protect and restore watershed function and fish habitat (USFS 1994).

The abundance and productivity viability parameters for ESA-listed salmon and steelhead in the Sandy River Basin have also been adversely affected by degraded habitat resulting from mining, agriculture, and residential and commercial development. Mining of sand and gravel has historically occurred in the Sandy River Basin and this reduces habitat complexity, channel stability, and available spawning gravels (Taylor 1998). Mining in the Sandy River delta area ended after designation of the Columbia River Gorge Scenic area in 1986. Agricultural use was common in the lower basin and continues today, although some land has been converted to residential and commercial uses.

After World War II, many dairy and row crop farms were abandoned, reverting to forest, particularly those on steep slopes. This trend was reversed by development pressure in the late 20th century. Smaller communities along U.S. Highway 26 in the upper basin joined the high population growth trends of the lower basin cities. These activities have impacted habitat conditions in the lower watershed as wetlands and floodplains were drained and filled, riparian

vegetation was removed, and water was diverted for irrigation and other uses. Between 1982 and 1992, 100 acres of wetlands and 1,800 acres of forest were converted to other uses, primarily residential development (SRBWC 1999). A National Resources Inventory inventoried land cover and use, soil erosion, prime farmland, wetlands, and other natural resource characteristics on non-federal rural land in the United States. Based on the inventory from 1982 to 1997, approximately 5,700 acres of cropland, pasture, range and forestlands were converted annually to urban use in the basin (SRBP 2005).

Alterations to conditions within the wetted channel and to adjacent riparian areas in reaction to previous flood events and in preparation for future events also greatly affected ESA-listed salmon and steelhead productivity and abundance. During the 1960s, the lower reaches of the Salmon River, Zigzag River, and Still Creek were all straightened and channelized, as a result, cover for fish in the form of large wood and boulder substrate was removed, side-channel/off channel refuge areas were eliminated, and riparian habitat was simplified (Taylor 1998). Together, all of these activities substantially decreased the complexity and productivity of the habitat and contributed to a decline in the natural populations.

Municipal Water Supply and Hydropower Development

The quantity and quality of habitat in the Sandy River Basin has also been affected by municipal water supply activities, which have impacted salmon and steelhead in the basin. These activities began in the late 1800s, as the City of Portland sought to provide its citizens with water from the Bull Run River, a Sandy River tributary. The facilities were expanded in the early 1900s, including a crib structure in 1915, which raised Bull Run Lake's storage capacity, Headworks Dam built in 1922 (with no fish passage facilities)(Bull Run Dam #2, Figure 1), and Ben Morrow Dam in 1929 (Bull Run Dam #1, Figure 1). Since 1922, the Headworks Dam has reduced spatial structure, particularly for spring Chinook salmon, by blocking access to approximately 37 miles of high-quality spawning and rearing habitat in the upper Bull Run system. In addition, the quality of habitat for salmon and steelhead in areas that remained accessible downstream from the dam, approximately 6 stream miles, was degraded by water diverted at the Headworks Dam. The diversion reduced flows in the lower Bull Run River, from late spring to fall, and limited recruitment of gravel and large woody materials that had once created high quality, diverse fish habitat. In April 2009, the City of Portland completed a 50-year HCP to comply with the ESA for its Bull Run municipal water supply facilities. The HCP includes 49 measures to protect and improve habitat, to avoid or minimize the impacts from the Bull Run water supply system, and to mitigate for lost salmon production (i.e., hatchery production intended to replace lost spring Chinook salmon natural production). These measures were designed to address the flow, temperature, and habitat impacts of the water supply system.

Under the 50-year agreement, habitat above the dams in the Bull Run River would remain inaccessible to salmon and steelhead, and this would continue to restrict spatial structure. However, the HCP includes actions that are expected to improve salmon and steelhead habitat in the six mile free-flowing section below the Headworks Dam by maintaining minimum flows that would help reduce water temperatures and improve spring Chinook salmon holding habitat; and through the placement of gravel and large-woody debris below the dam to provide spawning and rearing habitat (Portland Water Bureau 2013). These actions, along with the flow changes are expected to improve productivity in the lower Bull Run River for spring Chinook salmon.

Hydropower facilities were developed on the Sandy and Little Sandy Rivers in the early 1900s (Figure 1). The Bull Run Hydroelectric Project was constructed in 1912 and included the Little Sandy River diversion dam. The diversion dam on the Little Sandy River was 16 feet high and blocked access to 8.3 miles of salmon and steelhead habitat. It also reduced streamflows in the 1.7 mile reach between the diversion dam and the confluence with the Bull Run River affecting productivity and abundance. The Bull Run Hydroelectric Project included 30-foot-tall Marmot Dam, which diverted water from the mainstem Sandy River to the Little Sandy River directly above the diversion dam via a network of canals and tunnels. The diverted water ended up in Roslyn Lake, the reservoir for the Bull Run powerhouse located on the Bull Run River (acclimation site, Figure 1).

Prior to 1951, the diversion canal at Marmot Dam was unscreened and a large percentage of the outmigrating salmon and steelhead smolts were lost when they were diverted into Roslyn Lake and the Bull Run powerhouse (SRBP 2005). This resulted in reduce productivity and abundance, primarily for spring Chinook salmon and steelhead. The screens installed in 1951were adequate for larger fish but were not successful in protecting fry and small fingerlings (Mattson 1955). From the 1950s until 1973, flows between Marmot Dam (RM 30) and the mouth of the Bull Run River (RM 18.5) were at such low levels during the summer months that spring Chinook salmon passage was not possible. Minimum flows below Marmot Dam were established in 1973 and maintained to provide minimal passage and rearing habitat in the 11.5 mile section. Marmot Dam had a fish ladder that was continually being rebuilt and improved because of damage by flood waters. These improvements throughout the decades helped to increase upstream fish passage and when Marmot Dam was rebuilt in 1989, fish passage was improved still further, maintaining access to the upper Sandy River Basin.

Beginning in 1999, the fish ladder at Marmot Dam was used to trap and remove hatchery adults, resulting in a *de facto* “wild fish sanctuary” above the dam. The fish ladder, however, was not designed for, and was never intended for, the trapping and removal of adult salmon and steelhead, and thus the operation proved harmful to natural-origin fish that were mixed together and handled with hatchery fish (D. Cramer, pers. comm., Portland General Electric, Project Biologist, February 24, 2012). In 2007, Marmot Dam and its associated facilities were removed, ending the ability to trap and remove hatchery fish; this was followed in 2008 by the removal of the diversion dam on the Little Sandy River.

In 2010, ODFW announced its intention to identify and manage areas in the LCR in Oregon above existing fish trapping facilities as “wild fish sanctuaries” (ODFW 2010a). Areas would be managed as “wild fish sanctuaries” where an existing structure or facility allowed for the effective removal of hatchery fish. The areas identified were all above existing facilities or in watersheds where hatchery fish were not released, and were not selected based on other considerations (e.g., habitat condition, importance to fish). It is uncertain if the habitat above the former Marmot Dam can be defined as a “sanctuary,” since the dam was removed 3 years prior to ODFW’s announcement for wild fish sanctuary management. Regardless, the area above the dam is important habitat for salmonid recovery.

The removal of Marmot Dam and the Little Sandy River Diversion is having a number of beneficial effects on salmon and steelhead VSP parameters. After the initial disturbance and short-lived period of increased turbidity as accumulated sediment washed downstream, conditions for fish have greatly improved. The removal of Marmot Dam and the associated facilities eliminated injury and mortality to downstream migrating juvenile fry and pre-smolts encountering the fish screens, and the survival of this alternative life history trait is expected to improve. The dam's removal also resulted in the full volume of flow remaining in the river channel instead of being diverted, as well as eliminating the direct and delayed mortality to natural-origin fish caused by trapping and handling at the dam. These benefits from the removal of Marmot Dam are expected to improve salmon and steelhead abundance and productivity in the Sandy River and to contribute to recovery.

In addition to the beneficial effects from removing Marmot Dam in 2007, similar benefits are resulting from the removal of the diversion dam on the Little Sandy River in 2008. This remediation is increasing the spatial distribution of coho salmon and steelhead by restoring access to 8.3 miles of habitat in the upper Little Sandy River that has been inaccessible since 1912. It has also restored flows to the lower section of the Little Sandy River from the old diversion site to its confluence with the Bull Run River. Now that access to these areas has been restored and salmon and steelhead have begun to seed these historical production areas, there has been increased productivity and abundance as measured by juveniles outmigrating from the Little Sandy River (Strobel 2014).

Hatchery Production

There is a long history of artificial propagation in the Sandy River Basin and Craig and Suomela (1940) and Taylor (1998) provide a detailed history of the hatchery programs. The initial hatchery facility was the Salmon River Hatchery on Boulder Creek that was established in 1896 and operated intermittently through 1912 collecting eggs from Chinook salmon, coho salmon, and steelhead for rearing on station and at other facilities. In 1912, the operation at the Salmon River Hatchery was moved to a new facility constructed directly below Marmot Dam due to concerns about fish being able to pass above the dam. The new facility operated intermittently from 1913 to approximately 1950, producing Chinook and coho salmon and steelhead (Taylor 1998), but the facility was abandoned in the late 1940s when facility problems caused hatchery production to decline. In anticipation of the construction of the Sandy Hatchery, the Marmot Dam facility was operated to collect eggs that were reared at Bonneville Hatchery for release back into the Sandy River at the Sandy Hatchery (Taylor 1998).

In 1950, the Sandy Hatchery was constructed and its initial operation depended on juveniles shipped in from Bonneville Hatchery and from spring Chinook salmon collected at Marmot Dam. From 1954 to the early 1960s, the hatchery primarily used Sandy River spring Chinook salmon and coho salmon for broodstock in an attempt to increase returns. Production during this period was highly variable with egg-takes ranging from 29,000 to 404,800 winter steelhead, 196,425 to 716,000 coho salmon, and 10,280 to 1,619,650 spring Chinook salmon (note that fall Chinook salmon were also reared in some years, and the Chinook salmon egg-takes were combined, e.g., the 1,619,650 total)(Taylor 1998). In the mid-1960s, early-returning Big Creek stock winter steelhead (not part of the LCR Steelhead DPS) from LCR hatcheries were first released to support an early winter steelhead fishery (Taylor 1998). Annual Big Creek stock

winter steelhead releases averaged around 200,000 smolts (Figure 5). Beginning in the 1970s, production at the Sandy Hatchery changed, and it only produced coho salmon for release on station (Taylor 1998). Beginning in the 1970s, spring Chinook salmon from the Clackamas River (not part of the LCR Chinook ESU) and non-endemic summer steelhead were released into the Sandy River and its tributaries to increase returns to the Sandy River and to support fishing opportunities.

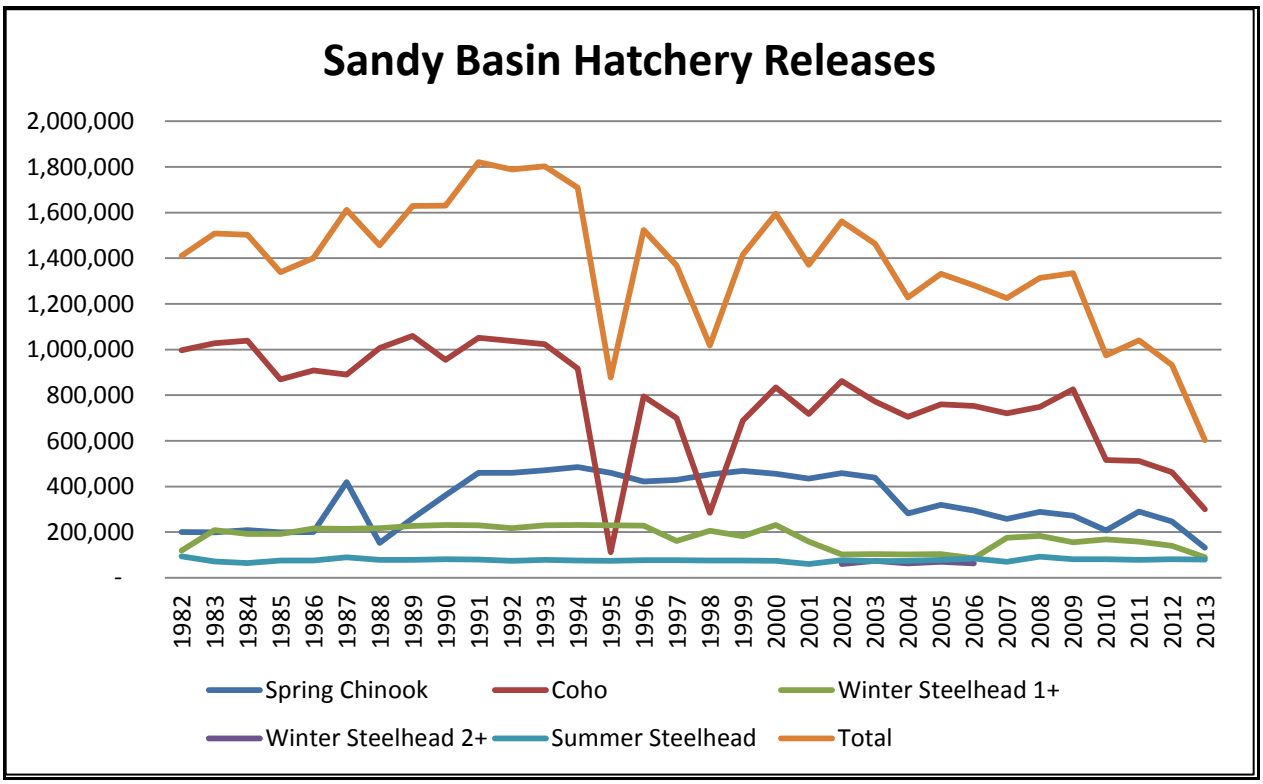

Figure 5. Sandy River Basin hatchery releases by year of release from 1982 to 2013. Data from 1997 draft Sandy River Basin Management Plan (ODFW 1997), Sandy HGMPs (ODFW 2013e; 2013d; 2013c; 2013b), and queries into the Fish Passage Center Hatchery Database.

In 1999, NMFS issued a Section 7 Jeopardy Opinion for all Federally funded artificial propagation (hatchery) programs in the Columbia River Basin affecting Snake River Spring/Summer Chinook Salmon, Snake River Fall Chinook Salmon, Snake River Sockeye, Snake River Summer Steelhead, Upper Columbia River Summer Steelhead, and LCR steelhead (those salmonid species listed in 1999) (NMFS 1999). Because the opinion reached a jeopardy determination, the opinion includes Reasonable and Prudent Alternatives (RPAs) that would avoid jeopardy. The RPAs stated that

> "All action agencies shall manage adult hatchery stray rates to the lowest level achievable. For non-indigenous salmon and steelhead, stray rates shall not exceed 5% of the annual natural population size in the receiving stream. For within ESU-origin stock outplanted for fishery augmentation/mitigation programs steelhead

stray rates shall be managed between 5-30% of the annual natural population (NMFS 1999).“

NMFS’ 1999 opinion also issued Conservation Recommendations, non-mandatory but considered important, intended to further remedy hatchery practices adversely affecting ESA-listed salmon and steelhead including:

- Minimizing inter-basin stock transfers (moving one stock of fish from its original basin to another basin) in waters that support ESA-listed fish,
- Adopting measures to improve homing and reduce straying of all hatchery releases,
- Consider using acclimation ponds and volitional release strategies to reduce potential straying and minimize potential competition between hatchery fish and listed salmon and steelhead,
- Monitor and evaluate ecological interactions between listed salmon and steelhead and hatchery releases in nursery and rearing areas,
- Monitor and evaluate predation by residualized hatchery steelhead and identify alternative methods/schemes to reduce steelhead residualism,
- Conduct spawning ground carcass surveys to determine the composition of listed and hatchery fish in the naturally spawning population,
- Modify the hatchery programs in areas of ESA-listed natural-origin fish to include a conservation role along with an enhancement role, and
- Adopt strategies to separate returning hatchery fish from listed naturally spawning fish including, but not limited to, releasing hatchery fish outside primary spawning and rearing areas and dead-ending returns at weirs (NMFS 1999).

When this opinion was issued only LCR steelhead were listed under the ESA in the Sandy River. The final ESA-listing determination for Sandy River spring Chinook salmon occurred around the same time that the 1999 hatchery opinion was signed. Many, if not all, of the recommendations listed above were implemented by ODFW working with NMFS as described below. These recommendations were also applied to the other Sandy River hatchery programs.

Sandy River Hatchery Programs

Below is an overview of how the hatchery programs have been operated over time, their effects, both positive and negative, on the ESA-listed species, and how these programs and their effects have changed since the reviews by McElhany et al. (2007) and Ford (2011).

For Sandy River spring Chinook salmon, some reduction in the VSP parameters likely occurred as a result of genetic introgression, competition, and predation during the 20 to 30-year period when broodstock practices used fish originating from outside the Sandy River Basin, and pHOS was high. As described previously in this subsection, the local spring Chinook salmon broodstock program at the Sandy Hatchery was maintained using adults collected at Marmot Dam until the program was terminated in 1975 (Taylor 1998). For a period beginning in the 1970s and prior to broodyear 2002, all spring Chinook salmon released into the Sandy River Basin were from outside the ESU (i.e., Upper Willamette River or Clackamas River stock). During the 1990s, approximately 450,000 smolts were released annually into the Sandy River

(Figure 5) and there was concern that Clackamas River stock spring Chinook salmon may be overwhelming and replacing the Sandy River natural-origin spring Chinook salmon population such that the spring Chinook salmon population in the Sandy River might become genetically indistinguishable from the Clackamas River hatchery spring Chinook salmon due to high pHOS leading to genetic introgression (ODFW 1998).

However, in 1999, NMFS completed a status review under the ESA (64 FR 14308) and concluded, based on best available information, that the Sandy River spring Chinook salmon population was still distinct from the Clackamas River spring Chinook salmon population and included the Sandy River population within the LCR Chinook Salmon ESU. In 2006, Myers et al. (2006), in reviewing genetic data and previous evaluations (Bentzen et al. 1998; NMFS 1998), observed that Sandy River spring Chinook salmon were genetically intermediate to other LCR spring Chinook salmon populations and to the Clackamas River spring Chinook salmon population. They concluded that notwithstanding the higher than normal rates of interbreeding that has likely occurred between Clackamas River spring Chinook salmon (Upper Willamette River ESU) and Sandy River spring Chinook salmon, the Sandy River spring Chinook salmon population still retains some of its original genetic characteristics (Myers et al. 2006).

To address concerns with genetic introgression by Clackamas River spring Chinook salmon, ODFW initiated the development of a localized Sandy River spring Chinook salmon broodstock after it was determined that the natural-origin Sandy River spring Chinook salmon were distinct from Clackamas River spring Chinook salmon (Myers et al. 2006). Beginning in 2002, only natural-origin (unmarked) spring Chinook salmon were collected at Marmot Dam for broodstock as part of the transition away from Clackamas River spring Chinook salmon to a locally-derived (native) broodstock. Clackamas Hatchery spring Chinook salmon were marked with an adipose fin-clip beginning with the 1997 broodyear such that all of the returning hatchery spring Chinook salmon would be distinguishable from the natural-origin Sandy River spring Chinook salmon. The last release of Clackamas River spring Chinook salmon was in 2002 and the number of smolts release annually was reduced from approximately 450,000 to 300,000 beginning with the 2002 broodyear (Figure 5). In 2002, all of the returning Clackamas Hatchery spring Chinook salmon were distinguishable from other spring Chinook salmon except for a very small percentage (less than 2 percent) that would have been unmarked 6-year-old hatchery adults. By return year 2008, the transition to the locally-derived broodstock was complete and all returning Sandy River hatchery adults originated from Sandy River spring Chinook salmon. Beginning in 2008, only a proportion (approximately 30 percent) of the broodstock consisted of natural-origin adults, the rest consisted of returning hatchery adults. Since the 2011 broodyear, only returning Sandy Hatchery adults have been used for broodstock.

Myers et al. (2006), determined that even though there was introgression with Clackamas River spring Chinook salmon, the natural population still retained some of its original genetic characteristics and thus natural-origin Sandy River spring Chinook salmon were included in the LCR Chinook Salmon ESU. This determination in combination with the use of natural-origin adults for hatchery broodstock and the successful and complete transition to a locally-derived broodstock program bolstered NMFS' decision to include the Sandy Hatchery spring Chinook salmon program in the ESU and to consider it integrated with the natural-origin population (NMFS 2003a; 2004b; Ford 2011; Jones 2011).

The change to the locally-derived Sandy River spring Chinook salmon broodstock has eliminated one ongoing threat to the diversity and productivity parameters – the genetic effect from introduced exogenous spring Chinook salmon into the Sandy River Basin. A second threat to diversity is hatchery-influenced selection from hatchery origin adults spawning naturally. In this case, pHOS is used to approximate the degree of hatchery-influenced selection (Subsection 4.3, Effects on Anadromous Fish Listed under the ESA).

Following dam removal, pHOS reached extreme levels before ODFW began instituting measures to control pHOS, and recent surveys have shown a declining trend in pHOS for spring Chinook salmon (Table 5). From 1999 through 2007, hatchery origin spring Chinook salmon were collected and removed at Marmot Dam, thus controlling pHOS in the upper Sandy River Basin. After the removal of Marmot Dam and without the ability to trap and remove hatchery adults, pHOS increased substantially to as much as 77.1 percent (Table 6). These levels vastly exceeded the management and recovery plan pHOS goal of less than 10 percent, developed by ODFW through the modeling of recovery scenarios in the ODFW Recovery Plan (ODFW 2010a). The pHOS goal for the Sandy River spring Chinook salmon population and its supporting information and analysis was incorporated into the NMFS' final Recovery Plan for ESA-listed species in the LCR (NMFS 2013c). The HSRG (2009c) recommends for natural populations that are managed to achieve high viability (i.e., high persistence or very low risk of extinction), that the Proportion Natural Influence (PNI)[7] should exceed 0.67 (see detailed discussion of PNI in Subsection 4.1, Potential Hatchery Effects). As described in Subsection 4.1, Potential Hatchery Effects, PNI is a function of pHOS and pNOB (the proportion of natural-origin adults in the hatchery broodstock) (HSRG 2004; 2009c).

NMFS analyzed annual PNI values for return years 2008 through 2013 (Table 6). Because hatchery-origin spring Chinook salmon returning in 2008 and 2009 had only natural-origin parents, PNI for those years met HSRG recommendations or approximately 0.67. The weighted mean pNOB was calculated for each return year based on the proportion of each broodyear in the spawning population (from scale-based age estimates) and the pNOB for that proportion's broodyear. As pHOS increased and pNOB decreased, PNI declined to a low of 0.54 in 2011. A PNI greater than 0.50 indicates that the population has a greater tendency for adapting to the natural environment than to the hatchery environment (HSRG 2014) (Subsection 4.3, Effects on Anadromous Fish Listed under the ESA). PNI has been increasing primarily because pHOS has been decreasing, and pNOB for the returning adults remained high. In 2013, PNI was 0.77 in part due to a pHOS of 9.3 percent, which was consistent with the recovery and management goal of a pHOS less than 10 percent.

Even with the increasing PNI and decreasing pHOS, high levels of pHOS from 2008 to 2012 may have reduced the productivity of the natural-origin spring Chinook salmon population. The HSRG (2014), in order to limit adverse genetic and ecological impacts on natural-origin populations that are managed to achieve high viability, recommends that pHOS for integrated

[7] This metric was not considered in the previous biological opinion and Environmental Assessment because natural-origin adults were not incorporated into the broodstock and, therefore, the primary management goal was to achieve the pHOS goal of less than10 percent.

programs such as this should not exceed 30 percent. As indicated in Table 6, the pHOS levels were well above this recommended level for return years 2008 to 2011.

As described above, the Sandy River spring Chinook salmon population was impacted through genetic introgression from the release of Clackamas Hatchery spring Chinook salmon over the 20 plus year period from the late 1970s until 2001. The effect from this introgression was to shift the genetic representation of the Sandy River spring Chinook salmon population from that similar to other LCR Chinook salmon ESU populations to one that was intermediate between the LCR and Upper Willamette Chinook salmon ESUs (Bentzen et al. 1998). The most recent genetic data and analysis by Hess et al. (2012a), using Sandy River spring Chinook salmon samples collected in 2006, show that Sandy River spring Chinook salmon were still intermediate between the two ESUs and the effects of genetic introgression were still present. There are no data available as yet to show whether the recent transition to a locally-derived broodstock is having the desired and beneficial affect such that the Sandy River spring Chinook salmon population is becoming more representative of the LCR ESU.

Table 6. Annual Proportionate Natural Influence (PNI) estimates for the Sandy River spring Chinook salmon naturally spawning population, based on the estimated proportion of hatchery origin spawners (pHOS) and the weighted mean for the proportion of natural-origin adults in the hatchery broodstock (pNOB) for each return year.

Return Year	Estimated pHOS (%)	Weighted Mean pNOB for returning adults (%)	PNI
2008	45.2	100.0	0.69
2009	53.0	100.0	0.65
2010	77.1	98.1	0.56
2011	66.5	76.8	0.54
2012	23.7	67.5	0.74
2013	9.3	31.2	0.77
Mean	46.2	78.9	0.66

Viability Analysis

A viability analysis addresses how the limiting factors (Subsection 3.3.1.3, Limiting Factors and Threats) affect the VSP parameters, which are used to determine the status of the natural-origin population. The viability analysis also describes how the status of the natural-origin population relates to the status of the ESU as a whole. NMFS' Northwest Fisheries Science Center scientists along with ODFW biologists evaluated the status of ESA-listed populations in the Willamette and Lower Columbia Basins as part of the Willamette/Lower Columbia Technical Recovery Team, and their modeling efforts were used in the development of ESA-recovery plans (McElhany et al. 2007). Their results for the LCR Chinook salmon populations in Oregon are illustrated in Table 6.

McElhany et al. (2007) determined that the Sandy spring Chinook salmon population was at a moderate risk of extinction (i.e., a persistence score of 2.5). In evaluating the VSP parameters for abundance and productivity they compared the time series from 1961 to 2004 with the 1990 to

2004 period and observed a general upward trend in abundance that mostly reflects the fact that up until the 1970s spring Chinook salmon passage upstream of Marmot Dam was severely restricted due to water diversions that dewatered the section of the Sandy River from Marmot Dam down to the mouth of the Bull Run River. The latter period also experienced high hatchery returns and a reduction in harvest rates compared to the 1961 to 2004 period. The abundance and productivity parameter score was 1.75 or high risk of extinction.

The spatial structure parameter for the Sandy River spring Chinook salmon population was given a score of 1.75, between a moderate and high risk, based on the 16 percent reduction in accessible habitat due to the dams on the Bull Run River. The reduction in spatial structure was ameliorated somewhat by the productive high quality habitat that still remains accessible in the upper basin tributaries (McElhany et al. 2007).

When developing the score for the diversity parameter, multiple elements were considered including life history traits, effective population size, impacts of hatchery fish, anthropogenic mortality, and habitat diversity (see Chapter 1 in (McElhany et al. 2007). When looking at the impacts from hatchery fish, McElhany et al. (2007) concluded that the risk to the natural-origin population is greatest when the pHOS is high and the genetic similarity of the hatchery fish to the natural population is low.

McElhany et al. (2007) used three different methods to evaluate the potential impacts of hatchery fish: (1) Proportionate Natural Influence (PNI) modeling for domestication in integrated hatchery programs, (2) Thresholds for hatchery introgression with out-of-stratum (MPG) hatchery broodstocks, and (3) Synthetic approach based on the fraction of hatchery-origin spawners (i.e., pHOS). These three methods are summarized here.

PNI is a useful tool to evaluate the genetic effects of a hatchery program, providing an indication of the extent to which the natural environment is driving the natural population as opposed to the hatchery environment (Subsection 4.3, Effects on Anadromous Fish Listed under the ESA). PNI modeling applies to hatchery programs that incorporate natural-origin adults into the broodstock, such as the proposed spring Chinook salmon and winter steelhead programs[8]. But this method does not apply to segregated programs that do not use natural-origin fish in the broodstock such as the coho salmon and summer steelhead programs, for these programs the other two methods are applied. If there is interbreeding between the natural population and hatchery fish from outside the MPG (i.e., potential genetic introgression), the effects cannot be easily estimated using the PNI/domestication method.

Thresholds for hatchery introgression involve the risk to the viability of the natural population from naturally spawning hatchery fish, which increases as the divergence of the hatchery fish from the natural population increases (i.e., risk from out-of-ESU/DPS spawners is greater than the risk from out-of-MPG spawners, which is greater than the risk from within the MPG). For example, the introgression threshold for an out-of-MPG hatchery program, as measured as the effective stray rate (where effective interbreeding is occurring), is less than 10 percent for a

[8] PNI is computed as pNOB/(pNOB+pHOS). This statistic is really an approximation of the true proportionate natural influence (HSRG 2009c, appendix A), but operationally the distinction is unimportant.

diversity score of 3 and less than 5 percent for a score of 4 (see Table 9 in (McElhany et al. 2007).

The synthetic approach considers domestication effects from integrated programs and out-of-MPG hatchery fish with a single framework based on pHOS. The rating system is a little different than the previous method because it makes no distinction for spatial or temporal segregation of hatchery and natural-origin spawners (i.e., reduced interactions between adult hatchery and natural-origin fish), only the estimated pHOS. If the hatchery fish are genetically more similar to the natural population then the score is higher relative to hatchery fish from a different MPG or ESU/DPS (see Table 10 in (McElhany et al. 2007).

The anthropogenic mortality element for the diversity parameter deals primarily with harvest rate but also includes impacts from habitat alterations and these can have different effects depending on the size, age, run-timing, or other traits of the natural population. The anthropogenic mortality rate must be less than 45 percent for a persistence score of 3 and less than 20 percent for a score of 4. McElhany et al. (2007) noted that the different types of mortality would have different selection effects and therefore different impacts on extinction risk and thus this method is a starting point for further evaluations.

The habitat diversity element for the diversity parameter is included because changes to habitat characteristics can lead to genetic changes through selection for locally adapted traits. These habitat changes can occur much faster than genetic changes, which can lead to the natural population not being able to adapt to a constantly changing set of habitat conditions (McElhany et al. 2007). As a result, habitat changes were used as a method to estimate potential changes in population diversity. To assess the risk from altered habitat diversity, they used historical habitat diversity as a reference point for evaluation.

To reach a final persistence score for the diversity parameter, McElhany et al. (2007) averaged all of the scores developed for this parameter as described above.

In developing a score for the diversity parameter for the Sandy River spring Chinook salmon population, McElhany et al. (2007) determined that life history traits have changed from what were there historically with spawn timing shifting from the period July to September as observed during the 1890s, to September and October, which is the norm now. The change in spawn timing is thought to be related to the introduction of Upper Willamette River spring Chinook salmon (Clackamas Hatchery stock) in the 1970s. The life history element was given a score of 2. The score for the effective population size element was 3, based on the estimated 28-year average abundance of 1,579 fish (1990 to 2004 period)(McElhany et al. 2007).

In looking at the impacts from the hatchery fish element, McElhany et al. (2007) reviewed data available through 2004. During the latter part of this period, ODFW was transitioning away from the releases of out-of-ESU Clackamas Hatchery spring Chinook salmon and developing a locally-derived broodstock program using Sandy River spring Chinook salmon. During this time, in 1999, the trapping and removal of hatchery spring Chinook salmon was also initiated at Marmot Dam. The estimated PNI was less than 0.65 above the dam and 0.25 below the dam leading to an overall persistence score of 2.5 for this factor. The hatchery introgression factor

score was 2 due to the introduction and long-term releases of Clackamas Hatchery stock spring Chinook salmon into the Sandy River Basin. The synthetic approach factor considered the spring Chinook salmon program that was developed from natural-origin locally-derived broodstock and concluded that there was likely a moderate level of genetic similarity between the hatchery fish and the natural spawning population, but a high level of similarity was not applied because of the history of non-native Clackamas Hatchery spring Chinook salmon. Because pHOS was between 0.10 and 0.30, the score for the synthetic approach factor was 4 (McElhany et al. 2007).

In development of the anthropogenic mortality element, harvest rates for Sandy River spring Chinook salmon were considered similar to those observed for Clackamas Hatchery spring Chinook salmon and for the period 1999 to 2002 the harvest rate was estimated to be 40.7 percent, with most of the impacts occurring in ocean fisheries (McElhany et al. 2007). They also noted that degradation and loss of habitat in the Sandy River, mainstem Columbia River, and in the estuary may have resulted in changes in the juvenile salmonid life histories. The score provided for the anthropogenic mortality element was 3 to 4.

Although the quality of habitat may be severely degraded the proportion and character (elevation and stream size) of accessible habitat reflected the historical conditions. The score for the habitat diversity element was 3.

Overall the score for the diversity parameter was 2.5, or moderate risk of extinction due to habitat changes and the legacy of the non-local hatchery fish introductions that affected the diversity score (Figure 6)(McElhany et al. 2007).

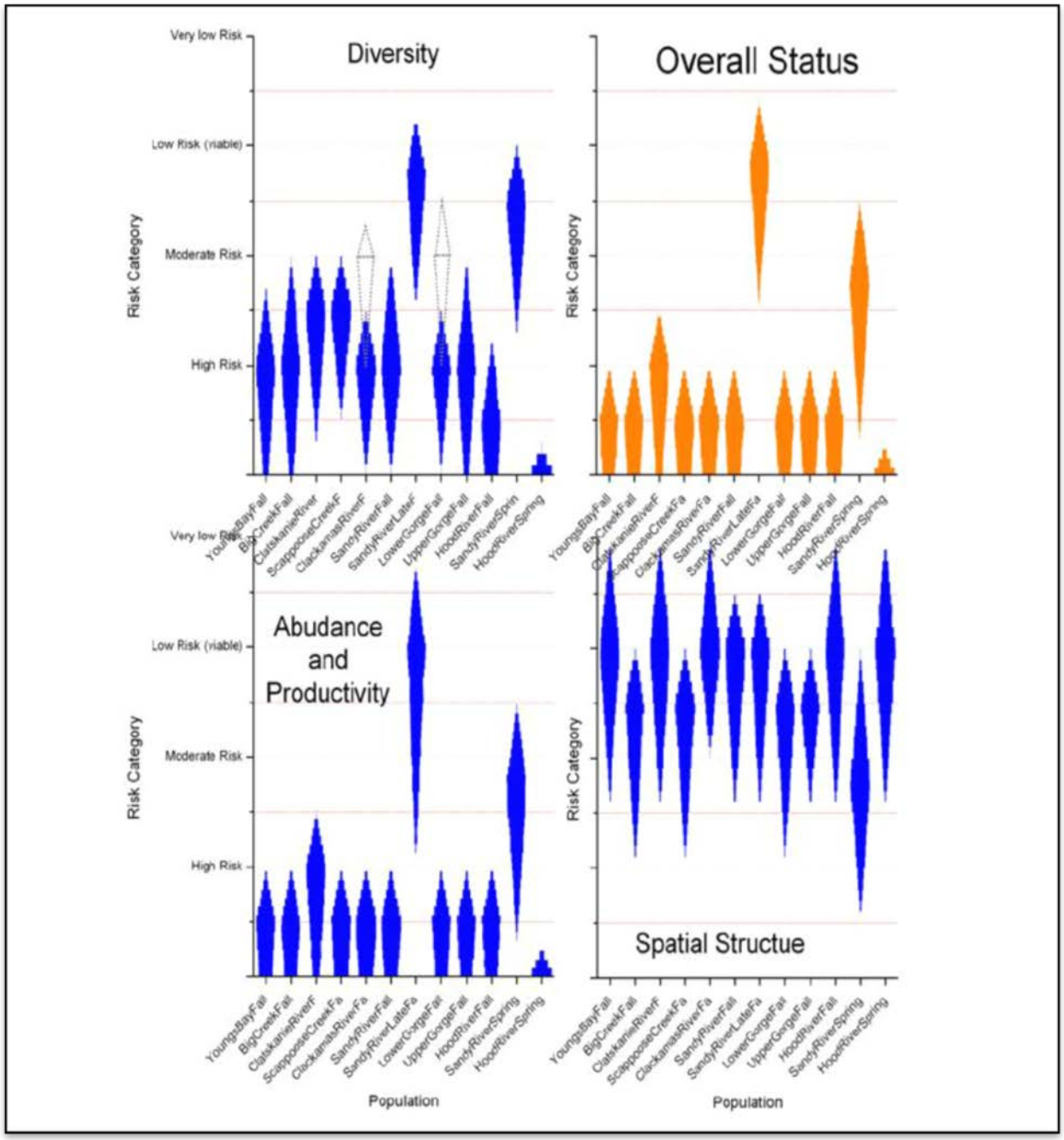

Figure 6. Oregon Lower Columbia River Chinook salmon status graphs and overall summery (Ford 2011).

Updated Viability Analysis

The following considers activities (e.g., the removal of Marmot Dam, changes in broodstock) that have occurred between 2004 (the last year of data used to evaluate the VSP parameters for the Sandy River populations by McElhany et al. (2007)) and 2013. NMFS analyzed the effects of these activities on the scoring of the individual VSP parameters and their constituent elements

for the Sandy River spring Chinook salmon population, and, ultimately, on the status of the ESA-listed population, to provide a baseline for comparing the effects of the alternatives.

Applying the VSP elements used by McElhany et al. (2007), after Marmot Dam was removed and the associated cessation of releases of Clackamas Hatchery spring Chinook salmon into the Sandy River was terminated, abundance and possibly also productivity have increased since 2004. Spatial structure has not increased substantially because most of the lost spring Chinook salmon habitat is still inaccessible above the dams on the Bull Run River. However, the removal of the Little Sandy River diversion dam has opened up some habitat for spring Chinook salmon and habitat restoration actions have increased habitat quality in some areas (particularly the lower Bull Run River and the Little Sandy River, but also in the upper Sandy River Basin as well) (Subsection 3.5, Instream Fish Habitat).

Factors affecting the diversity of the Sandy River spring Chinook salmon population may have improved in the time since the review by McElhany et al. (2007). The removal of Marmot Dam has benefited the spring Chinook salmon life-history that is expressed by fry and pre-smolt downstream migration due to the restoration of flows to the mainstem Sandy River and the absence of the diversion screens.

The mean abundance of natural-origin spawners has also increased slightly from an average of 1,579 reported by McElhany et al. (2007), to a recent average of 1,697 (2005 to 2013) (Table 5), thus potentially increasing the effective population size. The removal of Marmot Dam has changed the PNI calculation to reflect the entire basin, and from 2008 to 2013 the mean PNI has been 0.66 (Table 6), just below the level of 0.67 recommended by the HSRG and as described by McElhany et al. (2007) (see discussion of PNI in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA). With the exclusion of natural-origin adults in broodyears 2011, 2012, 2013, and 2014 PNI is expected to decline substantially to lows in 2016 and 2017 when pNOB is 0 for almost all of the returning adults.

The impacts of hatchery introgression due to releases from outside the population are expected to decline with the complete elimination of returning adults derived from Clackamas Hatchery spring Chinook salmon and the switch to a the locally-derived program. The score for the synthetic approach element may decline from what was estimated by McElhany et al. (2007), because of the high levels of pHOS observed since 2007. However, the score could be higher or stay the same because the hatchery spring Chinook salmon were derived from the natural population. The anthropogenic mortality element is not expected to change because harvest rates have remained similar to what was observed by McElhany et al. (2007), though there may be some increase in the score due to habitat improvements and the opening of habitat in the Little Sandy River. Overall, it is expected that the diversity parameter has increased from the 2.5 score in McElhany et al. (2007) because of the improvements in habitat and the declining impacts from the release of Clackamas River spring Chinook salmon.

In summary, the overall baseline status of the Sandy River spring Chinook salmon population is expected to improve after the habitat and hatchery actions currently being implemented as described above have time to reach their full affect. In the interim, the population remains at moderate risk of extinction.

3.3.2. Sandy River Coho Salmon

The Sandy River coho salmon population is part of the LCR Coho Salmon ESU, listed as threatened on June 28, 2005 (Table 1). The ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia River up to and including the Big White Salmon and Hood Rivers (Figure 7), and includes 25 hatchery programs. The Sandy Hatchery coho salmon program is considered to be part of the LCR Coho Salmon ESU (Ford 2011). Populations outside the action area would not be affected by the alternatives, so the Sandy River coho salmon population is the only coho salmon population that would be considered in this assessment.

The Sandy River hatchery program is not substantially diverged from the Sandy River coho salmon natural population (Ford 2011). NMFS identified four levels of divergence; minimal, moderate, substantial, and extreme. Minimal divergence means that, based on the best information available, there is no appreciable genetic difference between the hatchery stock and the natural population(s). Moderate divergence means the level of divergence between the hatchery stocks and the local natural population(s) is no more than what would be expected between two closely related populations within the ESU. Substantial divergence is roughly the level of divergence expected between more distantly related populations with the ESU. Extreme divergence is divergence greater than what would be expected among natural populations in the ESU, such as that caused by deliberate artificial selection or inbreeding (NMFS 2003a).

NMFS (2003a) determined that the Sandy River hatchery coho salmon program was no more than moderately diverged from the natural population in the watershed and that the stock was derived from the local, native population. The program is not considered to be minimally divergent because the hatchery program did not incorporate substantial numbers of natural-origin fish into the broodstock for most of its history. NMFS also determined that, because the Sandy River Hatchery coho salmon were no more than moderately divergent from the natural population, the program would be included in the LCR Coho Salmon ESU (NMFS 2004b). Based on this determination, NMFS considers the hatchery program to be representative of the natural population.

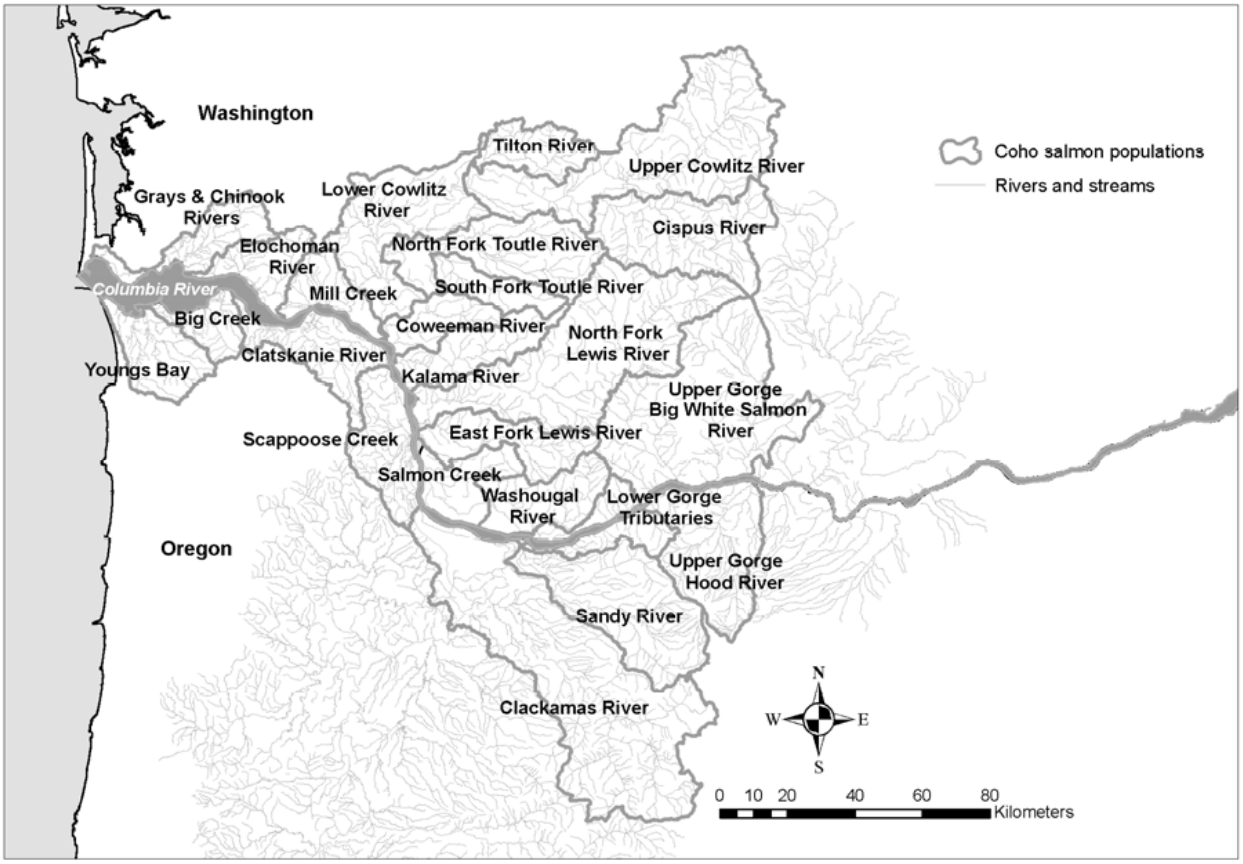

Figure 7. Historical Columbia River coho salmon populations (from (Myers et al. 2006).

3.3.2.1. Life History

LCR coho salmon show considerable temporal variability in river entry and spawn timing (LCFRB 2010). Columbia River coho salmon generally return in two runs:

- Early-returning (Type S) coho salmon enter the Columbia River in mid-August and begin entering tributaries in early September, with peak spawning from mid-October to early November.[9]
- Late-returning (Type N) coho salmon pass through the lower Columbia from late September through December and enter tributaries from October through January.[10] Most spawning occurs from November to January, but spawn timing can range into March. The onset of spawning is tied to the first substantial fall freshet. The salmon often mill near the river mouths or in lower river pools until freshets occur.

Coho salmon have discrete 3-year generations, meaning that each broodyear tends to return at the same age of three years, except for a small proportion that return after 5 to 7 months at sea (commonly referred to as "jacks") (this is different from Chinook salmon and steelhead). As a

[9] These are referred to as Type S because their ocean migration is generally south of the Columbia River.
[10] These are referred to as Type N because of a more northern ocean distribution.

result, coho salmon have fewer cohorts, there are three distinct cohorts in each population, and thus the health or status of each cohort needs to be given greater weight when determining the status of a coho salmon population.

In general, early returning fish spawn farther upstream than later migrating fish, which enter rivers in a more advanced state of sexual maturity (Sandercock 1991). In the LCR, peak spawning is in late October for early run coho salmon (Type S) and between December and January for late run coho salmon (Type N).

After emergence, coho salmon fry move to shallow, low velocity rearing areas, primarily along the stream edges and in side channels. All coho salmon juveniles remain in freshwater rearing areas for a full year after emerging from the gravel.

Most juvenile coho salmon migrate seaward as smolts in late spring, typically during their second year. Coho salmon use estuaries primarily to adjust physiologically to salt water. Most research indicates that, upon entering the ocean, coho salmon remain in near shore environments over the continental shelf for up to several months before they disperse.

3.3.2.2. Status and Trends

Ford (2011) recently updated the LCR coho salmon status review completed in 2005 (Good et al. 2005), concluding, consistent with previous evaluations that the ESU is currently at very high risk of extinction. Of the 27 historical populations in the ESU, 24 are considered at very high risk. The remaining three populations (Sandy, Clackamas, and Scappoose) are considered at high to moderate risk. Note that ODFW (2010a) determined that the Sandy River coho salmon population abundance and productivity parameter had decreased relative to that observed by McElhany et al. (2007), and this contributed to the lowering of the overall status to high risk (Figure 8). Factors affecting the VSP parameters have changed since the period considered by Ford (2011) and ODFW (2010a).

The majority of the coho salmon anchor habitat reaches are located in the upper Sandy River upstream of the confluence of the Sandy and Salmon Rivers and well upstream of the Sandy Hatchery where coho salmon are released (SRBP 2005). The majority of suitable spawning and rearing habitat is located above the former Marmot Dam site in the mainstem Sandy River, in the Salmon River and its tributaries below Final Falls, and in Still Creek. The only lower Sandy River tributary that was identified as coho salmon anchor habitat was Gordon Creek (SRBP 2005). Other lower river tributaries that are thought to support coho salmon included Cedar, Trout, Beaver, and Buck Creeks and the Bull Run River (NMFS 2008b). Critical habitat has not been designated for the LCR Coho Salmon ESU.

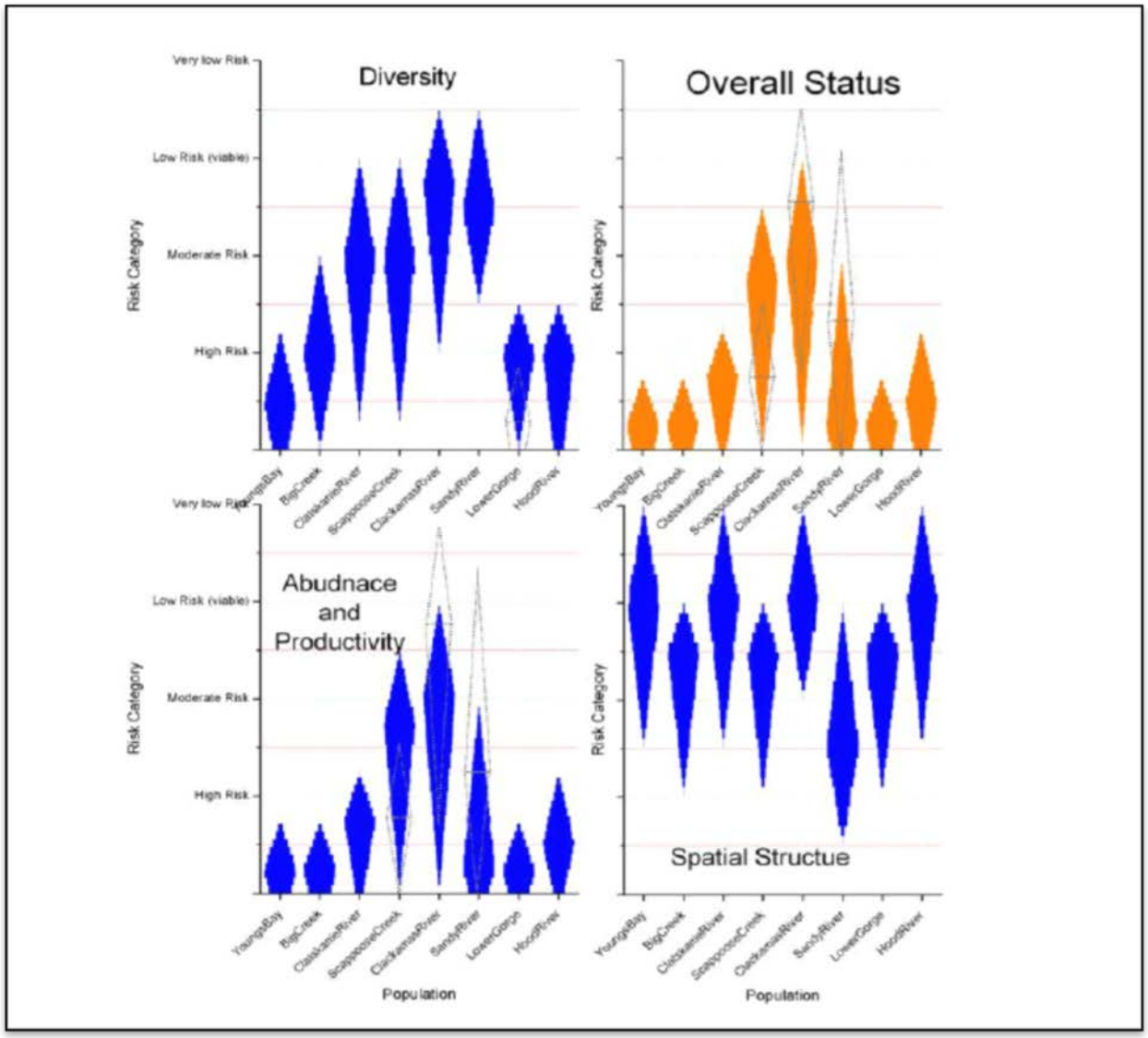

Figure 8. Extinction risk ratings for LCR coho salmon populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure as well as an overall rating for populations that combines the three attribute ratings. Where updated ratings differ from those presented by McElhany et al. (2007), the older rating is shown as an open diamond with a dashed outline (Ford 2011).

For coho salmon in the Sandy River Basin, the conservation and recovery plan for Oregon populations of salmon and steelhead (ODFW 2010a) identified reduced habitat complexity and diversity; access to off-channel habitats; reduced and degraded estuary habitat from hydropower system operations; and harvest in consumptive fisheries as the primary factors limiting coho salmon survival and recovery. Hatchery practices, including interactions on the spawning grounds with hatchery fish, were not considered a limiting factor. The hatchery weir located at the Sandy Hatchery on Cedar Creek was identified as a factor limiting adult escapement into Cedar Creek.

The recovery goal for Sandy River coho salmon, as described in Oregon's recovery plan (ODFW 2010a), is for the population to be at a low risk of extinction (less than 5 percent probability of extinction or a persistence score of less than 3) with an annual abundance of at least 5,685 natural-origin adults. In the NMFS' LCR Recovery Plan (NMFS 2013c), the Sandy River coho salmon population has a recovery target of high probability of persistence (Table 4), identifying it as key to the recovery of the Cascade coho salmon stratum, and the LCR Coho salmon ESU as a whole.

3.3.2.3. Limiting Factors and Threats

As described for spring Chinook salmon above, viability parameters and habitat in the Sandy River Basin have been affected by a number of factors over the course of decades. This has a largely been a consequence of the natural processes occurring in the basin as they interact with development and management activities that were implemented without adequate consideration or understanding for their effects. The Recovery Plan (ODFW 2010a) identified key limiting factors for Sandy River coho salmon, including reduced habitat complexity and diversity; access to off-channel habitats; impacts on the estuary habitat from hydropower system operations; and harvest in consumptive fisheries. Instances of stray hatchery coho salmon adults interbreeding with natural-origin adults were not considered a limiting factor. A secondary limiting factor for coho salmon adults in the Sandy River was habitat access, which was limited by the adult weir located at the Sandy Hatchery on Cedar Creek. These limiting factors may also be affected in the future by climate change, which would be expected to impact natural processes in the action area. These impacts are analyzed in Subsection 5.4, Climate Change. Impacts on estuary habitat from hydropower system operations and fishery harvest of coho salmon in consumptive fisheries occur outside the action area. Fisheries within the Sandy River Basin are selective for hatchery coho salmon, requiring the release of unmarked natural-origin coho salmon.

Resource Development, Municipal Water Supply, and Hydropower Development

Resource development and municipal water supply and hydropower development has similar effects on coho salmon viability as those described for spring Chinook salmon above. The secondary limiting factor that was identified by Oregon's Recovery Plan (ODFW 2010a) was blocked access to coho salmon spawning and rearing habitat in Cedar Creek above the Sandy Hatchery. In the past, the adult weir completely blocked passage at the Sandy Hatchery preventing natural-origin coho salmon from utilizing the habitat in Cedar Creek above the hatchery. Adult anadromous fish were not allowed to pass above the hatchery in an effort to prevent diseases and pathogens from entering the water supply for the Sandy Hatchery, and because the intake screens were not up to NMFS screening criteria. Since 2010, unmarked adult coho salmon have been released above the weir and the hatchery water intake screens and diversion structure were rebuilt in 2013, and now satisfy current NMFS screening and passage criteria. Passing natural-origin coho salmon above the weir to continue their migration restores access to an additional 12 miles of spawning and rearing habitat that has not been accessible since 1950.

Hatchery Production

The best available information for risk factors suggests that the coho salmon hatchery program has likely affected ESA-listed coho salmon in the action area. Some reduction in the VSP parameters likely occurred during the period when few natural-origin fish were incorporated into the hatchery broodstock, hatchery releases where high, pHOS exceeded 10 percent, and when hatchery facilities blocked access to spawning and rearing areas. Changes in these factors, during more recent years, are expected to greatly ameliorate these affects.

The Sandy River coho salmon program was first developed after the construction of the Sandy Hatchery, beginning with the 1952 to 1953 broodyears. For the duration of the program, hatchery broodstock has originated from the Sandy River Basin. The first broodstock were natural-origin coho salmon collected at Marmot Dam and since that time only hatchery returns from Sandy Hatchery releases have been used. Production at the Sandy Hatchery and annual smolt releases have declined by two thirds, from over 1.0 million in the late 1980s to the current level of 300,000 (ODFW 2013c)(Figure 5).

Hatchery coho salmon production was not distinguishable from natural-origin coho salmon until after the 1997 broodyear when 100 percent of the hatchery production was marked with an adipose fin-clip. Prior to that time, natural-origin coho salmon were incorporated into the broodstock annually, but the proportion was low, probably less than 3 percent (ODFW 2013c). Hatchery coho salmon were trapped and removed at Marmot Dam from 1999 until 2007 when the dam was removed. The number of hatchery coho salmon removed at Marmot Dam was very low, averaging less than 10 adults annually (Table 5). After the removal of Marmot Dam, basin-wide spawning surveys were conducted annually and the estimated pHOS varied from 0 to 12.4 percent from 2008 to 2012. The pHOS levels observed during this time reflect the number of adults returning from annual releases of over 720,000 smolts. The decline in pHOS observed in 2011 (8.4 percent) and 2012 (2.8 percent) reflect annual releases of 500,000 smolts that began in 2010 (Figure 5). The estimated high pHOS of 12.4 percent, observed in 2010, corresponds to a very large release of 826,083 smolts in 2009. The pHOS in 2013 of 11.8 percent was from a release of approximately 463,000 smolts.

Effects of ecological interactions between hatchery coho salmon and the natural-origin population have occurred and were most likely due to the large releases of smolts **(**Figure 5). Even with these large releases from the Sandy Hatchery few adult hatchery coho salmon from these large releases were observed at Marmot Dam (Table 5). When Marmot Dam was removed, the basin-wide spawning ground surveys found that pHOS was low to moderate as described above. The hatchery coho salmon program has not intentionally incorporated natural-origin adults into the broodstock and when it did occur it was only a small proportion of the broodstock and at levels that would not meet HSRG guidelines (Subsection 4.3, Effects on Anadromous Fish Listed under the ESA) (ODFW 2013c).

Even without the incorporation of natural-origin adults, NMFS determined that the Sandy Hatchery coho salmon program was part of the LCR Coho Salmon ESU because it had not substantially diverged from the Sandy River coho salmon natural population (NMFS 2003a; 2004b; Ford 2011; Jones 2011) and, therefore, NMFS considers the hatchery program to be integrated with the natural population.

Viability Analysis

McElhany et al. (2007) evaluated the status of the Sandy River coho salmon population using the methods as described above for spring Chinook salmon. They noted that because there are three separate cohorts for coho salmon that the minimum abundances need to be larger than for Chinook salmon and steelhead populations because of the high variability and the absence of a buffering effect provided by adults returning from overlapping broodyears. They determined that the abundance and productivity parameter was less than 1.5, or high risk of extinction because the mean abundance level had declined when comparing the two evaluation periods (1960 to 2005 and 1990 to 2005) and because one cohort was substantially lower than the other two.

At the time that the evaluation was completed, approximately 30 percent of the habitat that had been historically used by the Sandy River population had been blocked by dam construction on the Bull Run and Little Sandy Rivers, in addition to the blockage from the Sandy Hatchery weir on Cedar Creek. As with spring Chinook salmon, some of impacts from the loss of access to these areas were ameliorated because of the accessible productive habitat in the upper basin was of high quality. The score for the spatial distribution parameter was 1.5, or high risk (McElhany et al. 2007).

The elements used to develop the diversity parameter score for Sandy River coho salmon are the same as those described for spring Chinook salmon (i.e., life history traits, effective population size, impacts of hatchery fish, anthropogenic mortality, and habitat diversity). Regarding life history traits, McElhany et al. (2007) concluded that based on spawning records from the early 1900s and counts at Marmot Dam, that no large changes in life history had occurred. The score for the life history traits element was 3 or high persistence. The score for the effective population size element was 3 because the mean abundance was almost 500 adults (McElhany et al. 2007).

When looking at impacts from hatchery fish, McElhany et al. (2007) estimated that the basin-wide pHOS has been less than 10 percent over the last decade (thru 2004). This was based on 10 percent of the coho salmon production area being below Marmot Dam, and the remaining 90 percent above (as described above), and that the pHOS below the dam was high (less than 80 percent) in most years, but above the dam it was less than 5 percent. In addition, while evaluating this element, they considered that the hatchery program has been in operation for over 18 generations, has had less than 5 percent of the broodstock from natural-origin adults, and had very few introductions from outside the population. Based on the above information, they estimate that PNI was 1.0 above Marmot Dam and 0.1 below, leading to an overall score for this factor of 2.

The Sandy Hatchery coho salmon were considered to be part of the local population, and their effect was considered in the PNI factor, and out of basin strays are rare and thus they gave the hatchery introgression factor a score of 3 to 4 (McElhany et al. 2007). The synthetic approach factor used the estimated 10 percent pHOS for the entire basin, and the same information discussed above and gave the factor a score of 3.

With regards to the anthropogenic mortality element, harvest rates ranged from 75 percent to 90 percent from the 1950s to the 1990s and now range between 20 percent and 35 percent.

McElhany et al. (2007) identified the concern that past fisheries tended to select against adult returns from populations with a later run-timing, reducing the proportion of adults that spawn after December and as a result gave this element a score of 2. The loss of estuary habitat and Columbia River mainstem and side-channel habitat has been substantial since the mid-1800s, and as a result the habitat diversity factor score were adjusted downward to a score of 1.5. The overall diversity parameter score was 2.5, or a moderate risk of extinction (McElhany et al. 2007) (Figure 7).

McElhany et al. (2007), based on their evaluation of all the parameters, determined that the Sandy River coho salmon population was at moderate risk of extinction based on the combined score of 2.5 (Figure 8). This is considerable better than the extinction risk calculated for the ESU, which is considered at very high risk. The final overall score was less than 3, or moderate risk of extinction (Figure 8).

Updated Viability Analysis

The following considers activities (e.g., the removal of Marmot Dam, passage into upper Cedar Creek) that have occurred between 2004 (the last year of data used to evaluate the VSP parameters for the Sandy River populations by McElhany et al. (2007)) and 2013. NMFS analyzed the effects of these activities on the scoring of the individual VSP parameters and their constituent elements for the Sandy River coho salmon population and, ultimately, on the status of the ESA-listed population, to provide a baseline for comparing effects of the alternatives.

Applying the VSP elements used by McElhany et al. (2007), abundance has been variable since their review, depending on the individual cohort considered. There has been an increase in the abundance of the cohort that was previously identified as being substantially lower, while one cohort has remained about the same, and one cohort has declined (Table 5). Productivity would be expected to increase due to the additional available habitat and the elimination of passage impacts due to the removal of Marmot Dam, the removal of the Little Sandy River diversion dam, and the restoration of off-channel rearing and refuge areas.

Spatial structure has substantially increased with the removal of the Little Sandy River diversion dam. This has restored access to 8.3 miles of coho spawning and rearing habitat and improved the quality of habitat in the 1.7 miles of the Little Sandy River below the site of the diversion dam. Spatial structure has also increased because natural-origin coho salmon are now passed above the adult weir at the Sandy Hatchery. Passing natural-origin coho salmon above the weir to continue their migration restores access to an additional 12 miles of spawning and rearing habitat that has not been accessible since 1950. The increased access to habitat in the Little Sandy River and in Cedar Creek is expected to increase the spatial structure parameter for the Sandy River coho salmon population.

The diversity parameter is not expected to change substantially from what McElhany et al. (2007) concluded. Factors that might affect the life history traits element have not occurred, though the removal of Marmot Dam and restored access to habitat in the Little Sandy River and Cedar Creek may lead to the expression of a greater diversity of life histories for coho salmon than were observed in the Sandy River in the past. The effective population size element is also

not expected to change from what was observed in their review, with the annual abundance remaining above 500 (Table 5).

The removal of Marmot Dam has changed the pHOS calculation, such that it no longer looks at pHOS above and below Marmot Dam, but estimates pHOS for the entire basin. Natural-origin coho salmon are not incorporated into the broodstock so the PNI calculation is not appropriate. Thus, only the synthetic approach element would be applicable. As described above, pHOS for entire basin has ranged from 0 to 12.4 percent since the removal of Marmot Dam. The mean pHOS for this period was 7.12 percent and this would not change the score for this element from what was provided by McElhany et al. (2007). However, the average pHOS of 7.12 percent exceeds the less than 5 percent pHOS level for hatchery programs that do not incorporate natural-origin fish in the broodstock recommended by the HSRG (HSRG 2014). With regards to the anthropogenic mortality element, harvest rates have not substantially changed from what was considered by McElhany et al. (2007), and habitat improvements in the mainstem and estuary are such that the score for the habitat diversity element would probably not change, but improvements in habitat in the Sandy River Basin would contribute to a higher score. Overall, the diversity parameter score is not expected to change from the 2.5 provided in the 2007 review, but may change in the future as the effects of habitat improvements and the reduced hatchery coho salmon releases are reflected in fewer returning hatchery adults and potentially a lower pHOS (Figure 5).

In summary, the status of the Sandy River coho salmon population was assigned a moderate risk of extinction by McElhany et al. (2007), however, ODFW (2010a) determined that the productivity of the natural population has declined relative to the 2007 review. Their revision indicated that the Sandy River coho salmon population was at a high risk of extinction (low persistence score) (Figure 8). The overall status is expected to improve as productivity increases based on the addition of habitat in the Little Sandy River and upper Cedar Creek along with the potential benefits from the reduction in hatchery coho salmon production.

3.3.3. Sandy River Winter Steelhead

The Sandy River winter steelhead population is part of the LCR Steelhead DPS. The LCR Steelhead DPS includes all naturally produced steelhead in tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington and the Willamette and Hood Rivers in Oregon, excluding steelhead in the upper Willamette River above Willamette Falls (Upper Willamette DPS) (Busby et al. 1996) (Figure 9 and Figure 10). Steelhead in this DPS belong to the coastal genetic group (Schreck et al. 1986; Reisenbichler et al. 1992) and include both winter steelhead and summer steelhead. In the Sandy River, only winter steelhead are listed under the ESA; summer steelhead did not occur historically in the Sandy River (Figure 10), and the summer steelhead now present in the Sandy River originated from hatchery releases from a non-endemic stock and are not included in the ESA-listed DPS.

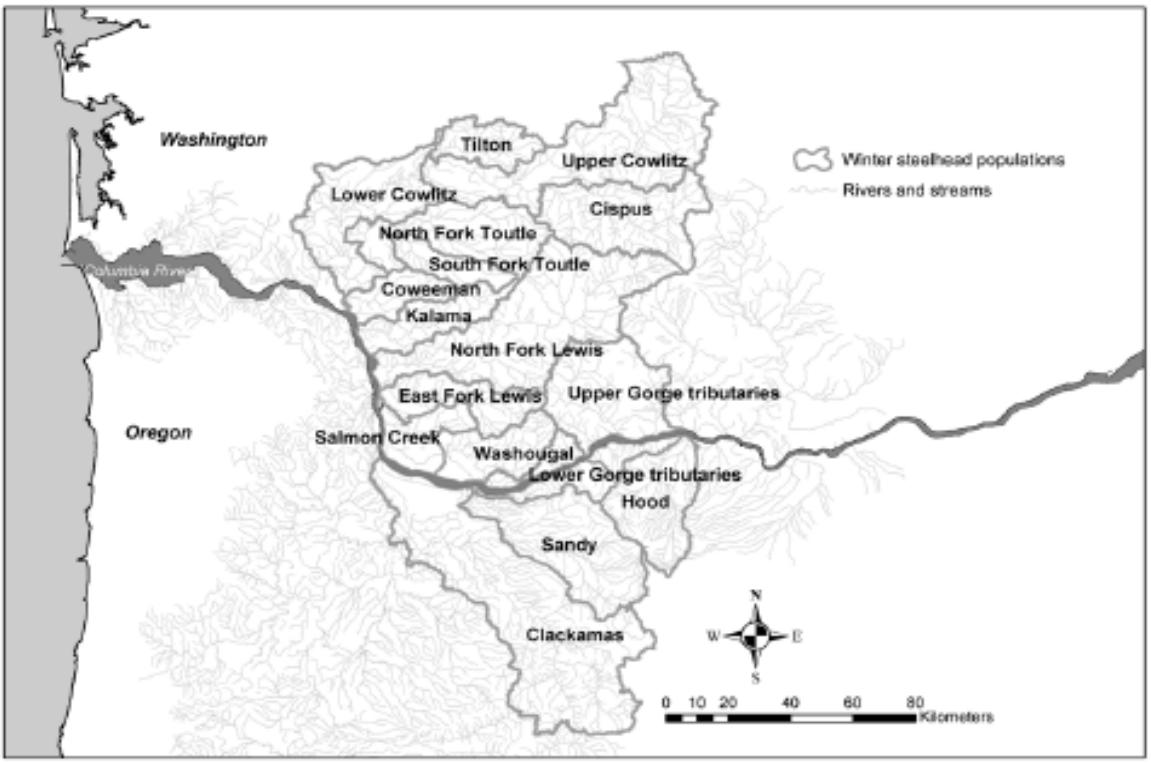

Figure 9. Historical Lower Columbia River winter steelhead populations (Myers et al. 2006).

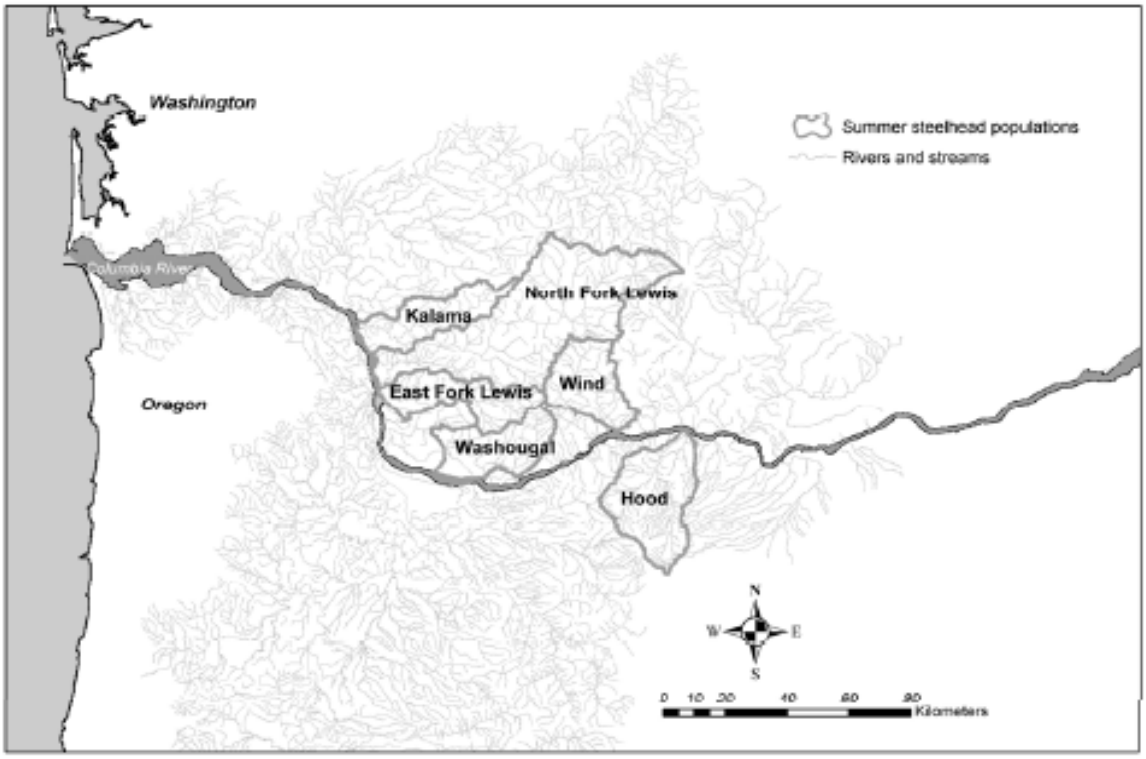

Figure 10. Historical Lower Columbia River summer steelhead populations (Myers et al. 2006).

The Willamette/Lower Columbia River Technical Recovery Team (Myers et al. 2003) identified 23 historical populations within the DPS and estimated that four historical populations have been extirpated (Figure 9 and Figure 10). Hatchery programs using endemic natural stocks of winter steelhead have been developed in the Cowlitz, Sandy, Kalama, and Hood River Basins and are considered to be part of the DPS (71 FR 834). The Sandy River winter steelhead hatchery program is not substantially diverged from the Sandy River winter steelhead natural population and, therefore, NMFS considers the hatchery program to be integrated with the natural population The scientific basis for this determination is provided by NMFS (2003a), NMFS (2004b), and Jones (2011). Populations outside the action area would not be affected by the Proposed Action, so Sandy River winter steelhead are the only ESA-listed steelhead population considered in this assessment.

3.3.3.1. Life History

Oncorhynchus mykiss has an anadromous form, commonly referred to as steelhead, of which LCR steelhead are a DPS, and a resident form generally referred to as rainbow trout (note that the resident form is not included as part of the ESA-listed DPS (71 FR 834)). They depend on freshwater areas for spawning and rearing and marine environments for growth and maturation. They differ from other Pacific salmon in that they are iteroparous (i.e., capable of spawning more than once before death). Post-spawning emigrating adult steelhead are referred to as kelts.

Steelhead are divided into two basic run types based on the level of sexual maturity at the time of river entry and the duration of the spawning migration (Burgner et al. 1992). The stream-maturing type (inland), or summer steelhead, enter freshwater in a sexually immature condition. The ocean-maturing type (coastal), or winter steelhead, enter freshwater with well-developed gonads and spawn shortly after river entry (Barnhart 1986). Variations in migration timing exist between populations. Both summer and winter steelhead occur in Washington and Oregon; Idaho has only summer steelhead (Busby et al. 1996). In the Pacific Northwest, summer steelhead enter freshwater between May and October, and winter steelhead enter freshwater between November and April. Summer steelhead usually spawn further upstream than winter steelhead (Withler 1966; Behnke 1992). Juveniles typically rear in freshwater from 1 to 4 years before migrating to the ocean. For winter steelhead, like those in the Sandy River, the norm is 2 years in freshwater (Busby et al. 1996). Steelhead typically reside in marine waters for 2 or 3 years before returning to their natal stream to spawn at age 4 or 5. Hatchery steelhead are reared to reach smolt stage in one year, thus hatchery steelhead return as age-3 or -4 adults after 2 or 3 years in the ocean with the majority returning as 3-year-old adults.

3.3.3.2. Status and Trends

Ford (2011) concluded, consistent with previous evaluations, that the DPS is currently at high risk of extinction. Of the 26 historical populations in the DPS, 17 are considered at high or very high risk. The Sandy River population is considered to be at high risk of extinction (Figure 11).

Table 5 provides escapement and hatchery proportion information for winter steelhead returning to the Sandy River. Prior to 2007, abundance estimates and the proportion of hatchery spawners were based on counts at Marmot Dam. Steelhead spawning ground surveys were conducted starting in 2010; however, surveys in 2010, 2011, and 2012 produced little reliable information.

Identifying marked fish and redds (i.e., salmonid nests with eggs) during winter steelhead spawning ground surveys is difficult due to high flows and turbidity that can occur during the winter and spring when the surveys are conducted. The 2010 survey included only seven individuals with known marks (i.e., those steelhead that were identified as either having an adipose fin-clip – a hatchery fish, or having an intact adipose fin – a natural-origin fish) identifying the origin of the fish, and the 2011 and 2012 surveys included 19 and 3 individuals with known marks, respectively. The very low number of known marked fish for these years resulted in very unreliable estimates of pHOS for those return years. Beginning in 2013, the surveys were expanded and the sample size increased to 47 known marked individuals. This resulted in an estimated total return of 3,747 adults of which 3,509 were natural-origin winter steelhead (ODFW 2013e). The pHOS estimate for 2013 was 6.4 percent. The expanded spawning ground surveys are expected to continue into the future and are expected to increase the reliability in the abundance and pHOS estimates.

ODFW estimates that 70 percent of the spawning habitat for winter steelhead is located above the former Marmot Dam site in the Salmon River and its tributaries and in Still Creek. Spawning habitat is also present in Clear Creek, Clear Fork, Lost Creek, Horseshoe Creek, Zigzag River, and Camp Creek. Key steelhead reaches include: the lower end of Trout Creek; the mainstem Sandy River from the mouth of the Bull Run River to RM 24; the mainstem Sandy River from the former Marmot Dam site to mouth of the Salmon River and the lower end of Wildcat Creek; the mainstem Sandy River from Salmon River confluence to the mouth of the Zigzag River and the lower end of Clear Fork and Lost Creeks; the lower Little Sandy River; the Salmon River downstream of Boulder Creek and the lower ends of Boulder Creek, Sixes Creek, and South Fork Salmon River; and the lower 10 miles of Still Creek (NMFS 2008b).

Stream reaches that were accessible to anadromous salmon and steelhead were designated critical habitat in 2005 (Table 1). The habitat above the Sandy Hatchery and those areas above the dams on the Bull Run River were excluded. PCEs, and their associated physical and biological features, for winter steelhead are the same as those described for spring Chinook salmon in Subsection 3.2.1, Sandy River Spring Chinook Salmon. The specific PCEs that apply to winter steelhead in the action area are freshwater spawning, freshwater rearing, and freshwater migration.

The conservation and recovery plan for Oregon populations of LCR salmon and steelhead (ODFW 2010a) identified reduced habitat complexity and diversity, including access to off-channel habitats; reduced estuary function from hydropower system operations; and gene flow between hatchery and natural-origin fish as factors limiting winter steelhead survival and recovery in the Sandy River.

The recovery goal for Sandy River winter steelhead, as described in Oregon's recovery plan (ODFW 2010a), is for the population to be at very low risk of extinction (less than 1 percent probability of extinction or a persistence score of 4) with an annual abundance of at least 1,519 natural-origin adults. Summer steelhead are not indigenous to the Sandy River and, thus, there is no recovery goal for these fish. The plan also recommended implementation of several actions or changes to the steelhead programs at the Sandy Hatchery that would benefit winter steelhead recovery and those actions are described in Table 9-3 of the plan (ODFW 2010a).

In the NMFS' LCR Recovery Plan (NMFS 2013c), the Sandy River winter steelhead population was identified as a core population with a recovery target of very high probability of persistence (Table 4), identifying it as key to the recovery of the Cascade winter steelhead stratum, and the LCR Steelhead DPS as a whole.

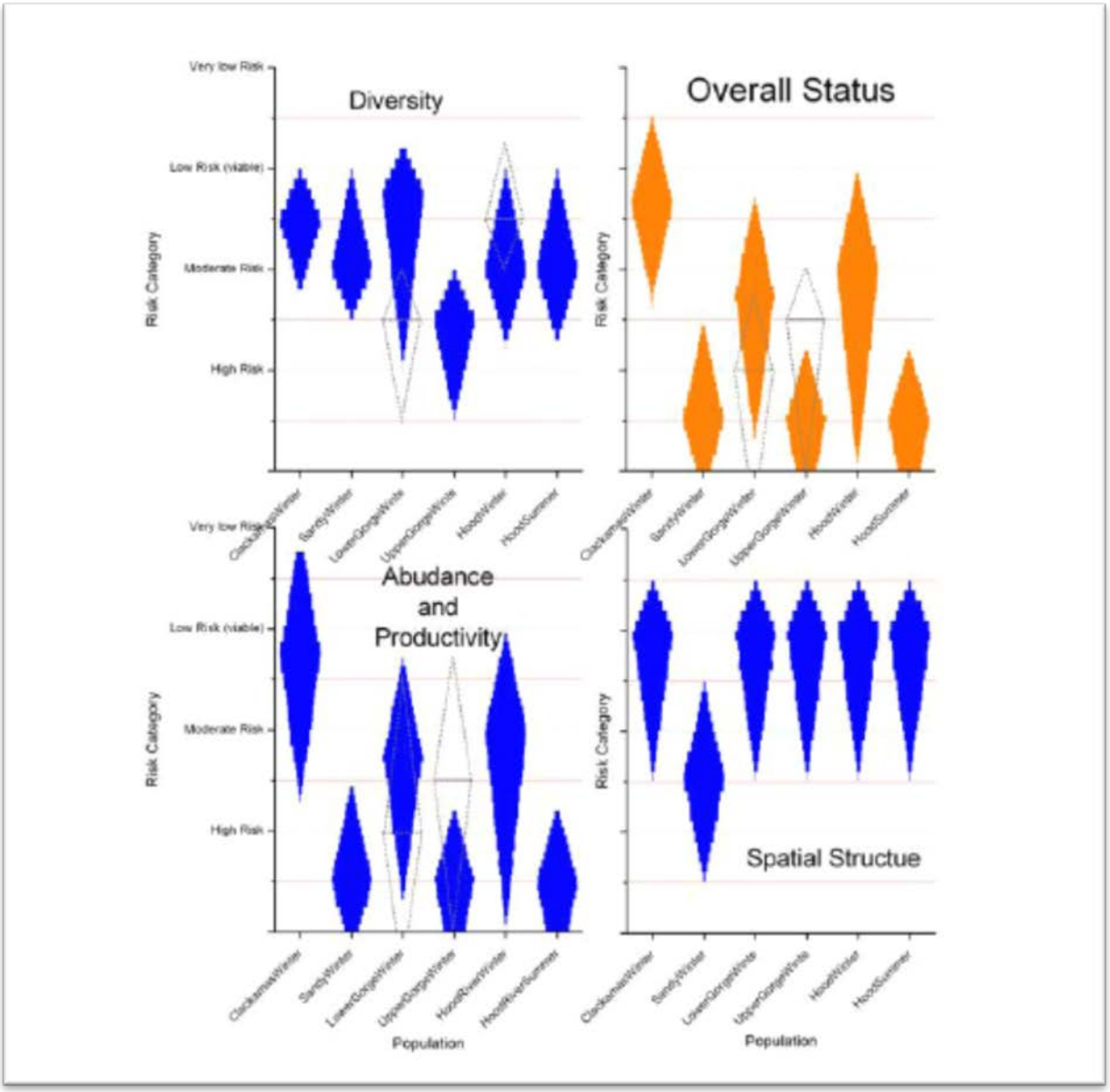

Figure 11. Oregon LCR steelhead population status from (Ford 2011).

3.3.3.3. Limiting Factors and Threats

As described for spring Chinook salmon above, viability parameters and habitat in the Sandy River Basin have been affected by a number of factors over the course of decades. This has a

largely been a consequence of the natural processes occurring in the basin as they interact with development and management activities that were implemented without adequate consideration or understanding for their effects. The Recovery Plans (ODFW 2010a; NMFS 2013c) identified as key limiting factors for Sandy River winter steelhead, including reduced habitat complexity and diversity, including access to off-channel habitats; impacts on the estuary habitat from hydropower system operations; and stray hatchery adults interbreeding with natural-origin adults. These key limiting factors may also be affected in the future by climate change, which would be expected to impact natural processes in the action area. These impacts are analyzed in Subsection 5.4, Climate Change. Impacts on the estuary habitat from hydropower system operations occur outside the action area. A secondary limiting factor for winter steelhead adults in the Sandy River was habitat access, which was limited by the adult weir located at the Sandy Hatchery on Cedar Creek.

Resource Development, Municipal Water Supply, and Hydropower Development

Resource development and municipal water supply and hydropower development has similar effects on winter steelhead viability as those described for spring Chinook and coho salmon above. The secondary limiting factor that was identified by Oregon's Recovery Plan (ODFW 2010a) was blocked access to winter steelhead spawning and rearing habitat in Cedar Creek above the Sandy Hatchery. Since 2012, adult unmarked winter steelhead have been released above the weir. Passing natural-origin winter steelhead above the weir to continue their migration restores access to an additional 12 miles of rearing and habitat that has not been accessible since 1950.

Hatchery Production

<u>Winter Steelhead Program</u>

In the 1999 Section 7 Jeopardy Opinion, NMFS identified that the greatest effect on LCR steelhead population productivity and diversity was caused by the natural spawning of non-endemic steelhead (NMFS 1999). An RPA for the Sandy River called for determining the origin of the existing naturally spawning steelhead in the Sandy River; the completion of an HGMP that proposed phasing-out the non-endemic Big Creek Hatchery winter steelhead program, and transitioning to a locally-derived Sandy River winter steelhead program; and until the transition to the locally-derived program was complete, restricting the release of Big Creek Hatchery winter steelhead in the Sandy River to below Marmot Dam, beginning in 1999 (NMFS 1999).

The Big Creek Hatchery early-winter steelhead releases began in the 1960s and, in some years, Eagle Creek Fish Hatchery winter steelhead (derived from the same stock) were also released into the Sandy River (Figure 5). Both of these are out-of-basin stocks, which likely resulted in substantial genetic introgression based on average pHOS estimates of 43 percent (Chilcote 1998).

After issuance of the ESA jeopardy opinion with RPAs, several actions were taken to ameliorate the affects from the release of Big Creek hatchery winter steelhead including reducing the number of smolts released and converting to a broodstock program using locally-derived natural-origin Sandy River winter steelhead. From 2000 to 2002, broodstock was comprised of 100

percent natural-origin Sandy River winter steelhead collected at Marmot Dam and from 2005 to 2010, a maximum 38 percent of the broodstock was composed of natural-origin winter steelhead. In 2011 this decreased to 18 percent, and for broodyears 2012 to 2014 only hatchery adults returning to the Sandy Hatchery were used for broodstock. The smolt release goal was 180,000 smolts and in some years (2002 to 2006) included releases of up to 74,000 2-year-old smolts (Figure 5). So, the hatchery program reduced its ongoing effects in two important ways – it changed to an appropriate, locally-derived broodstock and it properly sized the program from smolt releases of over 200,000 in the 1980s and 1990s to 160,000 beginning in 2009 (Figure 5) (ODFW 2013e).

As described above for coho salmon, beginning in 1999 all hatchery winter steelhead were trapped at Marmot Dam and removed (or recycled downstream for additional fishing opportunities). This continued until 2007 when Marmot Dam was removed. Table 5 provides escapement information for winter steelhead returning to the Sandy River. Note that prior to 2007 abundance estimates and pHOS were based only on counts at Marmot Dam.

Steelhead spawning ground surveys were not conducted in 2008 and 2009, but spawning ground surveys were conducted in 2010, 2011, 2012, and 2013, and estimates for pHOS for those years ranged from 0 to 28.5 percent. Estimates of pHOS in some years were unreliable due to the small sample size of winter steelhead used to estimate pHOS. For example, the pHOS estimate for 2010 was based on a sample size of only seven individuals with known marks identifying them as either a hatchery fish or a natural-origin fish. Of the two marked winter steelhead that were observed, one was observed above the mouth of Cedar Creek and one was observed below, and in close proximity to the hatchery such that both could have returned to the hatchery, considerably altering the final estimate of pHOS (Schroeder 2013). Small sample sizes like this could also underestimate pHOS. The 2011 and 2012 estimates were based on only 19 and 3 known-mark individuals. These small sample sizes reduce confidence in pHOS estimates for 2010, 2011, and 2012.

In 2013, the surveys were expanded to provide more data and generate better estimates of the abundance and pHOS than from prior surveys, and to ensure that the hatchery programs, as described in the 2012 HGMPs, were meeting the terms and conditions in the 2012 opinion. As a result of this expanded effort, the sample size in 2013, increased to 47 known marked individuals. This resulted in an estimated total return of 3,747 adults of which 3,509 were natural-origin winter steelhead (ODFW 2013e). The resulting pHOS estimate for 2013 was 6.4 percent.

In 2012, ODFW began releasing adult natural-origin winter steelhead into the habitat in Cedar Creek above the hatchery in anticipation of completing upgrades to the hatchery intake structure. In 2012, hatchery personnel released 34 natural-origin and 334 hatchery winter steelhead above the hatchery. The release of hatchery and natural-origin adults was done to fully seed the available spawning habitat. In 2013, these releases were reduced such that only 12 hatchery winter steelhead and 20 natural-origin winter steelhead were released above the weir. There is some concern that at this low level of escapement, demographic effects (e.g., not finding mates and low effective population size) may reduce the productivity of this subgroup of Sandy River winter steelhead. In 2014, 24 natural-origin adults and no hatchery winter steelhead were passed

above the hatchery. Over time the effects of these releases on productivity in Cedar Creek are expected to be monitored using a rotary screw trap to collect juvenile outmigrants.

Summer Steelhead Program

In 1975, Skamania-stock summer steelhead from the South Santiam Hatchery were first released into the Sandy River to create a summer recreational fishery. Since then, annual releases of summer steelhead have remained fairly consistent at approximately 75,000 smolts (Figure 5). Summer steelhead are not native to the Sandy River and are not part of the ESA-listed DPS. Prior to the listing of winter steelhead in the Sandy River, hatchery summer steelhead were periodically released into the Zigzag River, Salmon River, Still Creek, the upper mainstem Sandy River, and from a pond located directly below Marmot Dam. This practice of scattered releases around the basin ended more than 15 years ago with the intent of discouraging summer steelhead from returning to those areas and spawning naturally. Since 1998, all summer steelhead releases have been restricted to Cedar Creek at the Sandy Hatchery. This is designed to encourage hatchery summer steelhead to return to the hatchery and to reduce pHOS.

As described above, beginning in 1999 all hatchery summer steelhead were trapped and removed at Marmot Dam (or recycled downstream for additional fishing opportunities), however, all unmarked steelhead, including those passing during the summer steelhead period, were passed above the dam. Some of these unmarked summer steelhead were probably mis-marked hatchery steelhead (i.e., hatchery fish that should have been fin-clipped but did not get one) or offspring of naturally spawning hatchery summer steelhead, while others may have been natural-origin, ESA-listed summer steelhead straying into the Sandy River from other basins. All unmarked summer steelhead were passed above the dam under the assumption that such unmarked fish were out-of-basin ESA-listed summer steelhead that have naturally strayed into the Sandy River Basin. The trapping of marked hatchery steelhead continued until 2007 when Marmot Dam was removed.

Summer steelhead are not indigenous to the Sandy River, so there is some risk from genetic introgression when they spawn naturally, particularly if they spawn with natural-origin winter steelhead. Skamania-stock summer steelhead, used in the Sandy Hatchery summer steelhead program, are generally spawned at the South Santiam Hatchery from December through February – it is during the month of February that the spawn timing of the summer steelhead and Sandy River winter steelhead can overlap (Lewis 2013). The potential for summer steelhead to spawn naturally in areas occupied by winter steelhead has declined with the acclimation and release of hatchery summer steelhead at the Sandy Hatchery, which gives greater assurance that the hatchery summer steelhead would return to this location and, in time, prevent overlap with winter steelhead. However, the potential for overlap remains.

Currently, for winter steelhead in the Sandy River, NMFS looks at pHOS from any source, and makes certain assumptions about the relationship to the summer steelhead program. When the combined pHOS estimate for winter steelhead is greater than 5 percent (i.e., pHOS originating from all sources including the summer steelhead hatchery program), ODFW is required to conduct additional analysis to estimate the hatchery summer steelhead pHOS rate, reasoning that if the pHOS rate for the winter steelhead population was less than 5 percent then the pHOS rate attributable to summer steelhead spawning naturally would also be less than 5 percent.

Precise estimation of pHOS for summer steelhead is difficult because summer and winter steelhead redds cannot be differentiated morphologically. ODFW's current method is based on redds observed in February, the month in which summer and winter steelhead spawning could overlap (Lewis 2013). To error on the conservative side, all hatchery-origin spawners in February are assumed to be summer steelhead, and all redds are assumed to be from summer steelhead. The pHOS observed in February is then weighted by the proportion of redds in the entire winter steelhead monitoring season that are observed in February. For example, two steelhead were observed in February during the 2010 winter steelhead spawning survey, one with an adipose fin-clip and one unclipped, yielding a pHOS estimate for February of 50 percent (0.5). During that survey season, a total 231 redds were observe; two in February. The summer steelhead pHOS estimates for that survey season was 0.43 percent (0.5 x 2/231). In 2012, the pHOS for winter steelhead was 0 in February (i.e., no adipose fin-clipped fish observed) and as a result, the pHOS for summer steelhead was also 0.

This continues to be the preferred method to estimate pHOS for summer steelhead, though as described above for winter steelhead, the small sample size for these years limits the confidence in the final estimates. Confidence in the 2013 pHOS estimate increased because of the high number of known mark steelhead observed. ODFW applied the same analytical method because the 2013 pHOS for winter steelhead was estimated to be 6.4 percent. During February 2013, 15 steelhead were observed; all were determined to be unclipped, for a pHOS rate of 0 percent. As a result, the proportion of the natural spawning steelhead in 2013 that were summer steelhead was 0 (Brown 2014).

Summer steelhead have been released into the Sandy River since the 1970s, and ecological effects on the natural-origin winter steelhead population could have ranged from negligible to substantial during the period prior to the removal of hatchery summer steelhead at Marmot Dam. Returning hatchery summer steelhead that did spawn naturally would have produced juveniles that, depending on the spatial distribution and density of fish, could compete with natural-origin winter steelhead juveniles for food and habitat (Kostow and Zhou 2006). The removal of hatchery summer steelhead at Marmot Dam and the release of summer steelhead limited to below the dam has likely reduced the potential for ecological interactions that disadvantage winter steelhead, although unmarked summer steelhead were passed above Marmot Dam (Table 5). Following the best management practice of acclimating and releasing hatchery summer steelhead at the Sandy Hatchery – so they are more likely to return to the hatchery later as adults – is likely to contribute to achieving the pHOS goal of less than 5 percent for out-of-basin stocks from the 1999 Jeopardy Opinion RPA (NMFS 1999).

Viability Analysis

McElhany et al. (2007) evaluated the status of the Sandy River winter steelhead population using the methods described above for spring Chinook salmon. In looking at the abundance and productivity parameter, the long-term geometric mean was above the viable minimum abundance threshold of 850 natural-origin spawners, but the population showed very low productivity. The modeling showed that with the low productivity combined with a harvest rate of 39 percent, the population would have been in the "extirpated or nearly so" risk category. The abundance and

productivity parameter score for the Sandy River winter steelhead population was less than 1, or high risk of extinction (McElhany et al. 2007).

Regarding the spatial distribution parameter, McElhany et al. (2007) observed, as with coho salmon, that a substantial proportion of the historical winter steelhead habitat was inaccessible, but the habitat that was accessible, was of high quality, particularly in the upper Sandy River Basin. The score for this parameter was 1.5 or high risk of extinction.

The elements used to develop the diversity parameter score for Sandy River winter steelhead are the same as those described for spring Chinook salmon (i.e., life history traits, effective population size, impacts of hatchery fish, anthropogenic mortality, and habitat diversity). The only life history that was found to be native to the Sandy River Basin was that for winter steelhead. Spawning operations in the early 1900s indicated egg collection occurred from late March to the end of May, which is similar to current spawn timing for Sandy River winter steelhead. The age at return was believed to be consistent with what is observed for other populations in the Cascade Winter Steelhead strata. They concluded that there was little available information to determine if life history changes had occurred and provided a score of Not Applicable for the life history traits element (McElhany et al. 2007).

The Sandy River winter steelhead population was estimated to historically be in excess of 20,000 returning adults annually, but loss of habitat in the Bull Run River, Little Sandy River, and Cedar Creek Basins, along with impacts from water diversions at Marmot Dam reduced the run to 4,400 by 1954. In evaluating the effective population size element, McElhany et al. (2007), estimated natural-origin escapement was only 851 fish in 1997, but noted that it was difficult to distinguish natural and hatchery origin adults at that time. They gave the effective population size element a score of 2 to 3.

When evaluating the impacts from the hatchery fish element, McElhany et al. (2007) noted that hatchery releases of winter steelhead have been occurring since approximately 1900, and these releases were from broodstock collected from winter steelhead adults returning to the Sandy River. However, the hatchery programs have changed over time with releases of out-of-DPS Big Creek winter steelhead stock beginning in the 1960s, and the release of out-of-DPS summer steelhead beginning in the 1970s. Management changed beginning in 1999 when all hatchery steelhead were trapped and removed at Marmot Dam. The last release of Big Creek stock winter steelhead was in 2001 after ODFW developed a locally-derived broodstock program beginning with broodyear 2000, with the first release of smolts in 2001.

McElhany et al. (2007) determined that the impacts from the long history of out-of-basin stock releases could not be fully ameliorated by the removal hatchery adults at Marmot Dam and the conversion to the locally-derived broodstock, and as a result, gave the PNI factor a score of 1.5. Regarding the hatchery introgression factor, McElhany et al. (2007) noted that even with the long history of releases of out-of-DPS Big Creek stock winter steelhead and Skamania summer steelhead, they were not sure, due differences in spawn timing, to what extent interbreeding occurred between the hatchery steelhead and the native winter steelhead population and as a result they gave this factor a Not Applicable. At the time of their analysis, McElhany et al. (2007) noted that the hatchery situation was in transition with the termination of Big Creek stock

winter steelhead releases and the conversion to a locally-derived late winter steelhead program. From this, along with the removal of marked hatchery steelhead at Marmot Dam beginning in 1999, they concluded that the effective stray rate (pHOS) was near 0 (less than 0.5). But given the long history of hatchery releases in the basin they reduced the score by 1, with the resulting score for the synthetic approach factor being 3 (McElhany et al. 2007).

McElhany et al. (2007) concluded a score of Not Applicable for the anthropogenic mortality element even though harvest rates have declined from an average 40 percent prior to 1991, to approximately 4 percent with the initiation of selective fisheries regulations. They also noted that they could not quantify any life history diversity effects from changes in Columbia River mainstem and estuary habitat and, as a result, gave the anthropogenic mortality element a score of Not Applicable. The habitat diversity element was given a score of 2 to 3 due to the fact that the quality of the habitat has been severely degraded.

The resulting overall score for the diversity parameter was 2, or moderate, due to the potential effects from previous out-of-DPS hatchery releases that may have had considerable influence on the diversity of the natural population.

McElhany et al. (2007) determined based on their evaluation, as described above, that the Sandy River winter steelhead population was at high risk of extinction (Figure 11).

Updated Viability Analysis

The following addresses activities (e.g., the removal of Marmot Dam, passage into upper Cedar Creek) that have occurred between 2004 (the last year of data used to evaluate the VSP parameters for the Sandy River winter steelhead population by McElhany et al. (2007)) and 2013. NMFS analyzed the effects of these activities on the scoring of the individual VSP parameters and their constituent elements for the Sandy River winter steelhead population, and, ultimately, on the status of the ESA-listed population, to provide a baseline for comparing effects of the alternatives.

Applying the VSP elements used by McElhany et al. (2007), the abundance and productivity parameter score was less than 1 due to very poor productivity, which may be a reflection of the high pHOS observed prior to 1999, before returning hatchery steelhead were removed at Marmot Dam. Abundance has been highly variable, as described above, and may reflect the level of monitoring that did and did not occur since the removal of Marmot Dam (Table 5). The abundance measured in 2013 was the highest escapement of natural-origin Sandy River winter steelhead since 1992, and represents only natural-origin spawners. Before then, abundance was reported as a combination of hatchery and natural-origin winter steelhead spawning naturally (see Figure 10 in McElhany et al. (2007)). The continuation of intensive monitoring would determine if the 2013 escapement is an accurate indicator of the abundance, or a one-year spike in abundance. Productivity is expected to increase due to the proportion of hatchery winter steelhead spawners remaining low, the lower number of hatchery winter steelhead releases, and from the addition of spawning and rearing habitat.

Spatial structure has substantially increased with the removal of the Little Sandy River diversion dam, which has opened up 8.3 miles of winter steelhead spawning and rearing habitat and

improved the quality of habitat in the 1.7 miles of the Little Sandy River below the site of the diversion dam. Spatial structure has also increased because natural-origin winter steelhead are now passed above the adult weir at the Sandy Hatchery. The passage of natural-origin winter steelhead above the weir restores natural winter steelhead production in 12 miles of spawning and rearing habitat. ODFW estimates that the 12 miles of newly accessible habitat could support over 300 spawners. The increased access to habitat in the Little Sandy River and Cedar Creek is expected to increase the spatial structure parameter for the ESA-listed Sandy River for winter steelhead population.

The diversity elements that were assigned by McElhany et al. (2007), are not likely to have changed substantially over the last 10 years since the last review. Factors that might affect the life history traits element have not occurred, though the elimination of Marmot Dam and the newly accessible habitat in the Little Sandy River and Cedar Creek may lead to the expression of a greater diversity of life histories for winter steelhead compared to more recent times. The effective population size shows singes of increasing as described above, with the escapement of over 3,000 natural-origin winter steelhead in 2013. If this level can be maintained over time, the effective population size element would remain at a moderate to high persistence level.

McElhany et al. (2007) determined that the long-term impacts from the release of Big Creek stock winter steelhead on the natural-origin winter steelhead population had not been fully ameliorated by the removal of hatchery winter steelhead at Marmot Dam or the development of the locally-derived winter steelhead program. This element is expected to continue to improve since Big Creek stock winter steelhead are no longer being released and natural-origin winter steelhead have been used in the broodstock where pNOB ranged from 18 percent to 100 percent (broodyears 2000 to 2011). Using the same methodology described above for spring Chinook salmon, PNI was calculated for the years when pHOS was estimated. In 2010, PNI was 0.57, and 1 in 2011 and 2012 because pHOS was estimated to be 0 in those years (see the comment above about confidence in pHOS estimates for 2010 to 2012). The estimate for PNI increased to 0.80 in 2013. The average PNI for the period was 0.84 well above the HSRG metric of 0.67 for a population with high persistence and low risk recovery goal (HSRG 2004) (but with low confidence in the pHOS estimates for return years 2010, 2011, and 2012). The PNI metric would not be applicable for return years 2015 to 2017 because adults returning in those years are from broodstock made up of only hatchery winter steelhead.

The release of out-of-basin hatchery summer steelhead smolts in the upper Sandy River Basin and the resulting naturally spawning summer steelhead contributed to the low productivity observed for the Sandy River winter steelhead population (McElhany et al. 2007). Impacts on productivity have been substantially reduced with the termination of summer steelhead smolt releases in the upper Sandy River Basin, the removal of hatchery summer steelhead at Marmot Dam, and the release of hatchery summer steelhead restricted to the Sandy Hatchery. The long-term genetic effects from interbreeding between hatchery summer steelhead and winter steelhead are expected to be very low because there is very little if any overlap in spawn timing between hatchery summer steelhead and winter steelhead (Leider et al. 1984; Kostow et al. 2003).

The Sandy River winter steelhead population is still considered to be at high risk (low persistence) primarily due to low productivity (McElhany et al. 2007; ODFW 2010a; NMFS

2013c). The overall status of the natural population is expected improve as the addition of habitat in the Little Sandy River and upper Cedar Creek, along with improved abundance and the continued low levels of pHOS can increase productivity. Continued intensive monitoring of spawning escapement and juvenile out migration is expected to provide better information on the abundance and productivity of the Sandy River winter steelhead population than from past surveys.

3.3.4. Columbia River Chum Salmon

The Sandy River Basin is within the range of the Columbia River Chum Salmon ESU. This ESU includes all naturally produced chum salmon populations in the Columbia River and its tributaries in Oregon and Washington (Figure 12). Historically, chum salmon were abundant in the lower reaches of the Columbia River and may have spawned as far upstream as the Walla Walla River (Johnson et al. 1997). However, reductions in available habitat currently limit chum salmon in the Columbia River to tributaries below Bonneville Dam. The Upper Willamette/Lower Columbia River Technical Recovery Team has identified 16 historical populations in the ESU (Figure 12) (Myers et al. 2003). The Sandy River population is the only population within the action area.

Chum salmon spend 2 to 5 years in the northeast Pacific Ocean feeding areas prior to migrating southward during the summer months as maturing adults along the coasts of Alaska and British Columbia in returning to their natal streams (WDFW and PNPTT 2000). Most chum salmon mature as 4-year-old adults (Johnson et al. 1997). Chum salmon usually spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to nearly 62 miles from the sea. Chum salmon, like pink salmon, usually spawn in coastal areas, and juveniles migrate to seawater almost immediately after emerging from the gravel that covers their redds (Salo 1991). This means survival and growth in juvenile chum salmon depends less on freshwater conditions and more on favorable estuarine and ocean conditions.

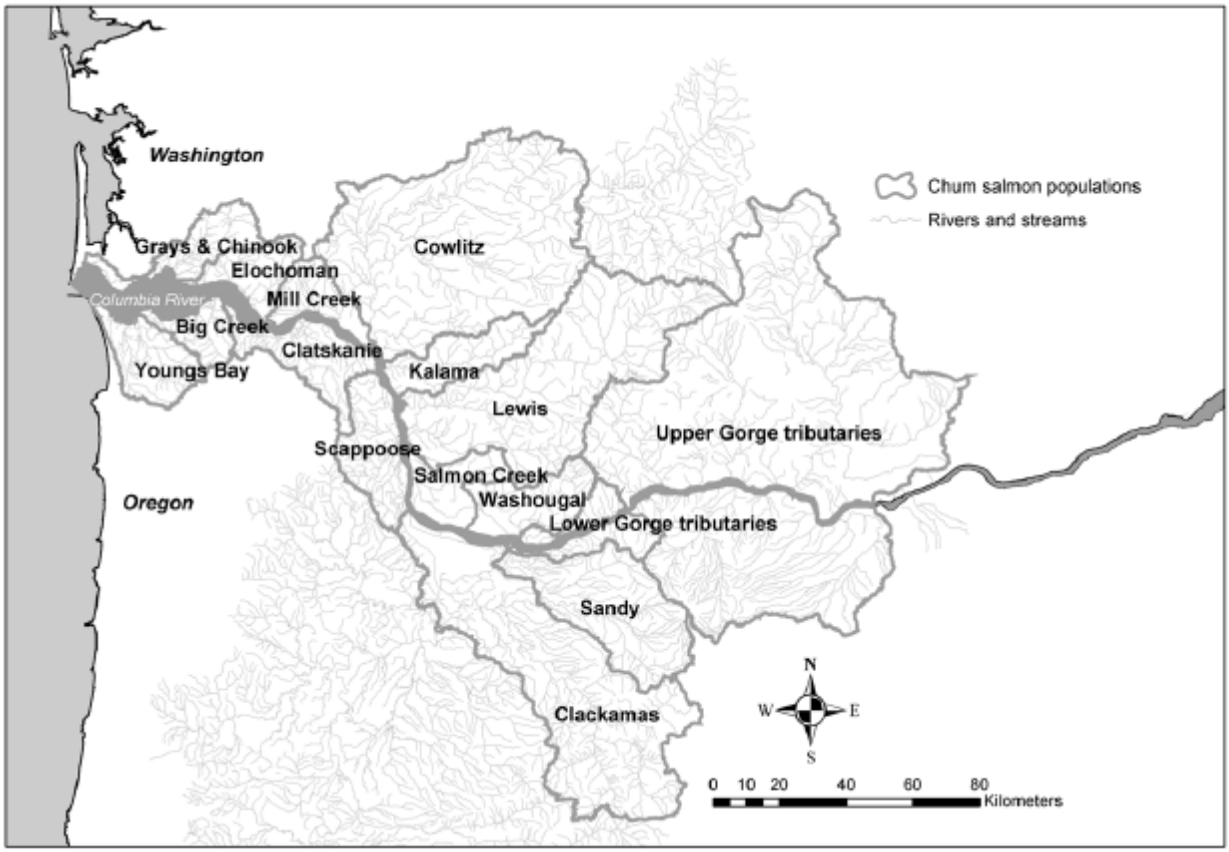

Figure 12. Historical Columbia River chum salmon populations (from Myers et al. 2006).

3.3.4.1. Status and Trends

Ford (2011) recently updated the status review completed in 2005 (Good et al. 2005) and found that the vast majority (14 out of 17) of Columbia River chum populations are extirpated. The Grays River and Lower Gorge populations showed a sharp increase in abundance in 2002, but have since declined and are at abundance levels in the range of variation observed over the last several decades. Chinook and coho salmon from the LCR exhibit similar trends, suggesting that observed increases in chum salmon abundance are likely related to ocean conditions. Chum salmon are considered extirpated from the Sandy River (ODFW 2005; McElhany et al. 2007). There is little information on the historical distribution of chum salmon in the Sandy River. Critical habitat was designated for the Columbia River Chum Salmon ESU, but did not include the Sandy River Basin (70 FR 52630, September 2, 2005).

Chum salmon have not been routinely observed in recent years during spawning surveys conducted for coho and Chinook salmon in lower Columbia tributaries, including the Sandy River. This lack of chum salmon spawners supports the likelihood that the Sandy River population has been extirpated.

3.3.4.2. Limiting Factors and Threats

The Recovery Plan (ODFW 2010a) did not identify any key limiting factors for Sandy River chum salmon except for those actions that address impacts on the Columbia River estuary. As described above, because chum salmon emigrate immediately after emerging from the gravel, habitat factors in the estuary and near ocean are more important to chum salmon survival than freshwater habitat in the tributaries. Estuary and ocean habitat actions occur outside the action area. If chum salmon return to the Sandy River Basin, then the secondary limiting factors including impaired upstream passage, altered hydrology, and excessive fine sediment could limit the viability of the natural population. These limiting factors may also be affected in the future by climate change, which would be expected to impact natural processes in the action area. These impacts are analyzed in Subsection 5.4, Climate Change. Chum salmon passage in several lower Sandy River tributaries could be impeded by barriers at road crossings, including culverts on Beaver and Buck Creeks in the lower Sandy River watershed.

The recovery goal for the Sandy River population of chum salmon, as described in the Recovery Plan (ODFW 2010a), is for the population to be at low risk of extinction (less than 5 percent probability). An annual abundance goal was not established for this population. There are no specific hatchery actions to address impacts of the Sandy River Hatchery programs on chum salmon, other than improving passage at the hatchery intake and adult weir on Cedar Creek, which has been completed.

3.3.5. Pacific Eulachon

On March 18, 2010, NMFS listed the southern DPS of Pacific Eulachon *(Thaleichthys pacificus)* as a threatened species (75 FR 13012) (Table 1). The eulachon spawning in the Sandy River are part of the southern DPS. The southern DPS extends from the Skeena River in British Columbia south to the Mad River in Northern California (inclusive) and, thus, all eulachon found within the action area are considered to be part of the threatened southern DPS of eulachon. Take prohibitions via section 4(d) of the ESA have not yet been promulgated.

3.2.5.1 Life History

Eulachon are endemic to the northeastern Pacific Ocean, ranging from northern California to southwest and south-central Alaska and into the southeastern Bering Sea. In the portion of the species' range that lies south of the United States–Canada border, most eulachon production originates in the Columbia River Basin. Within the Columbia River Basin, the major and most consistent spawning runs return to the mainstem of the Columbia River and the Cowlitz River. Spawning also occurs in the Grays, Elochoman, Kalama, Lewis, and Sandy Rivers. Adult eulachon have been recorded at several locations on the Washington and Oregon coasts, and they were previously common in Oregon's Umpqua River and the Klamath River in northern California. Runs occasionally occur in many other rivers and streams, although these tend to be erratic, appearing in some years but not others, and appearing only rarely in some river systems (Hay and McCarter 2000; Willson et al. 2006; Gustafson et al. 2010).

Eulachon in the Sandy River are generally typical of eulachon elsewhere. Eulachon generally spawn in rivers fed by either glaciers or snowpack and that experience spring freshets. It has

been suggested that, because these freshets rapidly move eulachon eggs and larvae to estuaries, it is likely that eulachon imprint and home to an estuary into which several rivers drain rather than to individual spawning rivers (Hay and McCarter 2000). Eulachon typically enter the Columbia River between December and May with peak entry and spawning during February and March (Gustafson et al. 2010).

Eulachon eggs, averaging 1 mm in size, attach to a variety of substrate types, from sand to pea-sized gravel. Newly hatched young are 0.16 to 0.25 inches (4 to 7 mm) in length and largely transparent. They are carried to the sea with the current. After the yolk sac is depleted, eulachon feed on pelagic plankton. After 3 to 5 years at sea, they return as adults to spawn. Adult eulachon weigh an average of 0.1 pounds each and are 6 to 7.8 inches (15 to 20 cm) long with a maximum recorded length of almost 12 inches (30 cm). They are an important link in the food chain between zooplankton and larger organisms. Small salmon, lingcod, and other fish feed on eulachon larvae, and eulachon juveniles and adults are an important food source for a variety of species, including Pacific salmon (Gustafson et al. 2010).

Critical habitat was designated for the southern DPS (76 FR 65324, October 20, 2011) (Table 1); in the Sandy River Basin, the area designated as critical habitat is in the lower part of the basin, extending from the mouth of the Sandy River upstream to the confluence with Gordon Creek (RM 12.8). This area is considered to include physical and biological features essential to spawning and incubation.

3.3.5.1. Status and Trends

There are few direct estimates of eulachon abundance. In some areas of the southern DPS where escapement counts or estimates of spawning stock biomass are unavailable, catch statistics are used to estimate relative abundance. However, inferring population status or even trends from yearly changes in catch statistics requires assumptions that are seldom met, including similar fishing effort and efficiency; assumptions about the relationship of the harvested portion to the total portion of the stock; and statistical assumptions, such as random sampling. None of these assumptions can be verified. There are few fishery-independent sources of abundance data available for eulachon, and there is an absence of monitoring programs for them (in the United States). However, the combination of catch records and anecdotal information indicate that eulachon were present in large annual runs in the past, and that substantial declines in abundance have occurred. Eulachon numbers are at, or near, historically low levels throughout the range of the southern DPS, including the Sandy River (Gustafson et al. 2010).

Persistent low returns and landings of eulachon in the Columbia River from 1993 to 2000 prompted the States of Oregon and Washington to adopt a Joint State Eulachon Management Plan (Subsection 1.6, Relationship to Other Plans and Policies) (WDFW and ODFW 2001). All eulachon fisheries in Washington and Oregon were closed in 2011, and are expected to remain closed pending substantial increases in returns.

3.3.5.2. Limiting Factors and Threats

Climate change impacts on ocean habitat are the most serious threat to persistence of the southern DPS of eulachon (Gustafson et al. 2010), but this habitat is outside the action area.

Other threats to the species include climate change impacts on freshwater habitat and habitat alteration and degradation from a variety of activities. The effects of climate change on eulachon are analyzed in Subsection 5.4, Climate Change. All other factors limiting the southern DPS, such as bycatch in shrimp trawl fisheries, occur outside the action area or would not be affected by the proposed hatchery programs.

The release of hatchery juveniles was not identified as a limiting factor, but eulachon may be impacted by hatchery fish through competition for space, and possibly predation on eulachon by salmon and steelhead juveniles. Predation by hatchery salmon and steelhead juveniles on newly hatched juvenile eulachon is assumed to occur if hatchery salmonid juveniles overlap with juvenile eulachon emigrating from the upper areas of the Sandy River Basin. The actual level of predation and the effects of that predation on eulachon in the lower Sandy River Basin are unknown and were not considered substantive compared to other factors identified as limiting the recovery of eulachon in the Columbia River (Gustafson et al. 2010).

3.3.6. Bull Trout

The U.S. Fish and Wildlife Service (USFWS) issued a final rule listing Columbia River DPS of bull trout (*Salvelinus confluentus*) as a threatened species under the ESA on June 10, 1998 (Table 1). At the time of listing the USFWS did not consider the Sandy River as bull trout habitat, and at that time there were no recent or historical accounts of bull trout occurring in the Sandy River (USFWS 2002). Since the listing bull trout have been sighted three times in the Sandy River (USFWS 2002). Anglers have caught and photographed two bull trout in the Sandy River Basin; one approximately 17 inches (43 cm) near the mouth of Gordon Creek in the vicinity of Oxbow County Park in November 1999, and another approximately 20 inches (51 cm) between Oxbow and Dodge Parks on January 23, 2002. The third observation was at the trap at Marmot Dam in May 2000 where an 18-inch (46 cm) fish was release upstream of the dam.

The USFWS (2002) stated that bull trout have been observed at and below Bonneville Dam on the Columbia River below the Hood River confluence indicating the possibility that bull trout from the Hood River may be foraging and/or overwintering in the Columbia River. Further, three records of bull trout in the Sandy River indicate additional possibilities: (1) the Sandy River watershed supports a population of bull trout; or (2) bull trout foraging and/or overwintering in the Columbia River, possibly from the Hood River population, may occasionally be entering the Sandy River or other tributaries downstream of the Hood River Recovery Unit. Bull trout are known to prey on both juvenile and adult salmon carcasses, but tend to have different habitat requirements from the other salmonid species, preferring habitat with cold water temperatures (USFWS 2002).

In the 2002 recovery plan, the Hood River Recovery Unit included both the Hood River and Sandy River Basins (USFWS 2002). At the time, the USFWS had identified one core area containing two populations in the Hood River and determined that the Sandy River also contained core habitat, but there was insufficient information on bull trout distribution and use of the Sandy River to identify it as a core area; however, additional information on bull trout use of the Sandy River as well as the mainstem Columbia River were defined as primary research needs (USFWS 2002). The basic research would include knowing where the bull trout observed in the Sandy River came from (i.e., are they migrants from other basins or is there a small remnant

population that has escaped detection?). This basin information is needed before research can be conducted to identify limiting factors and habitat needs for bull trout in the Sandy River.

ODFW includes the Sandy River within its Hood River Species Management Unit, but state that a self-sustaining population does not currently exist in the Sandy River. However, the recent bull trout sightings suggest that the Sandy River is a possible location for recovery (ODFW 2005). However, in 2010, the Sandy River was excluded from critical habitat designation for bull trout and those bull trout that have been observed in the past were considered to be from other basins and that their presence in the Sandy River was transient during foraging/overwintering migrations. In the revised draft recovery plan (USFWS 2014) the Sandy River Basin was not identified as being part of the bull trout core area for the Coastal Recovery Unit.

3.4. Non-listed Fish

The non-listed species in the action area include native species from the families Salmonidae (resident rainbow trout, whitefish), Catostomidae (suckers), Cyprinidae (northern pikeminnow, chiselmouth), Cottidae (sculpins), Petromyzontidae (lamprey), and Acipenseridae (sturgeon) (NMFS 2008b). There are also a number of introduced species present in the action area, but h not in abundance, including: Percidae (perch, walleye), Centrachidae (bass, sunfish, crappie), Ictaluridae (catfish, bullhead), Cyprinidae (carp), Clupiadae (shad). Most of these species are found in the lower reaches of the Sandy River, below the locations of the proposed weirs and juvenile hatchery fish release locations, where water temperatures are favorable (NMFS 2008b). Many of these species (e.g., northern pikeminnow, sculpins, walleye, bass, and crappie) prey on juvenile salmon and steelhead within the lower Sandy River.

Pacific lamprey (family Petromyzontidae) are a species of concern under the USFWS designation and are present in the action area; they currently occur in very small numbers (ODFW 2005). Pacific lamprey have not been captured or encountered during broodstock collection activities in the action area. The Sandy Hatchery adult weir blocked the upstream passage of lamprey in Cedar Creek for over 50 years. Upgrades to the adult weir and the hatchery intake structures, that were completed in 2012, included passage facilities for adult lamprey. For the first time, in 2014, juvenile Pacific lamprey have been recovered below the hatchery intake in the sediment settling chamber at the Sandy Hatchery. Adult lamprey are parasitic on other fish, including salmon and steelhead in the marine environment, but stop feeding when returning to spawn in freshwater.

Cutthroat trout (*Oncorhynchus clarki clarki*) are also a species of concern under the USFWS designation, and are found in the Sandy River (ODFW 2005). Abundance information is limited, and no studies have linked cutthroat trout abundance to the operation of hatchery programs. Cutthroat trout have been found in the action area during monitoring and evaluation activities, but at low numbers, such that abundance cannot be accurately estimated. For example, in 2013, during juvenile monitoring under the City of Portland HCP, screw traps within the Sandy River Basin collected 32 cutthroat juveniles and 22 adults (Strobel 2014).

The abundance of whitefish (*Coregonus spp*.) in the Sandy River is unknown. Whitefish distribution overlaps with anadromous salmonids in high, cool-water reaches of the basin, and they can compete for food with juvenile salmon and steelhead. Because of this overlap in

distribution, whitefish may be encountered at the proposed weirs in the upper basin. In 2013, four whitefish were encountered at the Zigzag weir and passed upstream, and two carcasses were recovered above the weir (Lackey et al. 2013). No whitefish were reported in 2013 at either the Salmon River or Bull Run River weirs (Lackey et al. 2013).

The abundance of resident rainbow trout is unknown, but their numbers are believed to be augmented by winter steelhead juveniles that do not emigrate from the Sandy River (ODFW 2005). The magnitude of the augmentation by the anadromous steelhead (both hatchery and natural-origin) would be affected by a number of factors, such as instream habitat, food availability, juvenile growth, and ocean conditions. The distribution of rainbow trout would be similar to that of anadromous steelhead and, as a result, they would compete with and prey on juvenile salmon and steelhead. Because of the similarity in distribution, resident rainbow trout may be encountered at the proposed weirs in the upper basin.

Recreational fisheries targeting most of these species occur in the Sandy River Basin and can overlap in time and area with fisheries targeting hatchery salmon and steelhead. Fisheries targeting warm-water species occur in the lower Sandy River Basin where water temperatures support those species. Fisheries for rainbow trout and whitefish occur in the basin, but tend to be restrictive through season and area closures, size limits, and bag limits to protect rearing and migrating juvenile salmon and steelhead. Fisheries in the Salmon River are limited to artificial flies and lures; bait can be used in the mainstem Sandy River below the Salmon River confluence. Gear types and fishery methods for salmon and steelhead differ from those for warm-water species; while non-listed species may be encountered during salmon and steelhead fisheries, the incidence is very low.

3.5. Instream Fish Habitat

The Recovery Plan (ODFW 2010a) identified the key limiting factors for Sandy River salmon and steelhead populations, including reduced habitat complexity and diversity and access to off-channel habitats. Reduced habitat quality, complexity, and connectivity with off-channel habitat were identified as key factors limiting juvenile fall, late-fall, and spring Chinook salmon viability in all population areas, including the Sandy River Basin (Subsection, 3.3.1, Sandy River Spring Chinook Salmon). These same factors were also found to be limiting coho salmon (Subsection, 3.3.2, Sandy River Coho Salmon), winter steelhead (Subsection, 3.3.3, Sandy River Winter Steelhead), and chum salmon (Subsection, 3.3.4, Columbia River Chum Salmon) abundance and productivity. Land use practices such as channelization, diking, wetland conversion, beaver dam removal, large woody debris removal, and gravel extraction have severed access to historically productive habitats, reduced the frequency of pools, simplified many remaining tributary habitats, and weakened the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production (ODFW 2010a). The installation and operation of weirs, such as those installed in 2011 in Cedar Creek, Zigzag River, and Salmon River, can also reduce connectivity (Subsection 2.1.1, Sandy River Spring Chinook Salmon Program).

Habitat restoration initiatives in the Sandy River Basin have begun to address major limiting factors for salmon and steelhead. In addition to the City of Portland's Habitat Conservation Plan (HCP), described below, a wide variety of restoration and recovery activities have been

undertaken in the action area. For example, programmatic Section 7 consultations with the U.S. Army Corps of Engineers (COE) for stream restoration and fish passage have been completed that authorize nine categories of actions, some of which have occurred in the action area (NMFS 2008d; 2014a). These are: boulder placement, fish passage restoration, spawning gravel restoration, large wood restoration, off- and side-channel habitat restoration, piling removal, set-back of existing berms, dikes and levees, streambank restoration, and water control structures.

Additional Section 7 consultations with other Federal agencies have been completed that expand on this list of restoration program activities to a total of 19 actions (NMFS 2008e; 2013b; 2013a):

- large wood, boulder, and gravel placement
- reconnecting existing side-channels and alcoves
- head-cut stabilization and associated fish passage
- streambank restoration
- fish passage at culverts and bridges
- screen installation and replacement at irrigation diversions
- nutrient enhancement
- floodplain overburden removal
- reduced recreation impacts
- estuary restoration
- riparian vegetation treatment (non-commercial, mechanical)
- riparian and upland juniper treatment (non-commercial)
- riparian vegetation treatment (controlled burning)
- invasive plant control
- fencing riparian areas (with water gaps and stream crossings)
- riparian vegetation plantings
- reducing sediment input from roads
- removal of legacy structures
- fisheries, hydrology, geomorphology, wildlife, botany, and cultural surveys in support of aquatic restoration

NMFS has also completed an ESA consultation on the activities of the NOAA Restoration Center in the Pacific Northwest (NMFS 2004a). These include participation in the Damage Assessment and Restoration Program, Community-based Restoration Program (CRP), and the Restoration Research Program. The CRP is a financial and technical assistance program that helps communities to implement habitat restoration projects. Projects are selected for funding based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Since 1999, activities authorized by the above consultations (and their predecessors) have been implemented in the Sandy River Basin where over 125 rehabilitation projects have occurred. Within these projects over 250 individual worksites have been identified where the rehabilitation

projects have been implemented (PNSHP 2014). These projects were funded through a number of different Federal agencies and through non-governmental organizations. Some of the projects that have been completed in the Sandy River Basin include large woody debris placement into Clear Fork, middle Sandy River, Zigzag River (multiple sites), and Salmon River (multiple sites); restoring channel connectivity and off channel habitat in Clear Creek, Zigzag River, and Salmon River; boulder placement at multiple sites in the Zigzag and Salmon Rivers; and invasive plant control, riparian plantings, and road obliteration throughout the basin (PNSHP 2014). The PNSHP (2014) has a database used to track salmon and steelhead habitat restoration projects in the Pacific Northwest that provides a list of projects that have been completed in the Sandy River Basin.

Other habitat restoration activities in the Sandy River Basin have been funded through the Pacific Coast Salmon Restoration Fund (PCSRF). The PCSRF was established by Congress to contribute to the protection and recovery of salmon and steelhead populations and their habitats (NMFS 2007a). The states of Washington, Oregon, California, Idaho, and Alaska, and the Pacific Coastal and Columbia River tribes receive Congressional PCSRF appropriations from NMFS each year. The funds supplement existing state, tribal, and local programs to foster development of federal-state-tribal-local partnerships in salmon and steelhead recovery. NMFS has established memoranda of understanding (MOU) with the states and with three tribal commissions on behalf of 28 Indian tribes; the 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 PCSRF projects. The PCSRF has made substantial progress in achieving program goals, as indicated in Reports to Congress, workshops, and independent reviews.

The lower Sandy River, including the river delta, is important habitat for fish, and two projects are nearly completed that would restore connections between large tracks of off-channel areas in the floodplain. Access to off-channel habitat has been identified as a primary factor limiting Chinook and coho salmon and steelhead abundance and productivity in the Sandy River Basin. At Benson State Recreation Area, a diversion structure is being modified to increase stream-flows, and a water control structure is being removed in the Sandy River delta that impeded fish passage into and out of important off-channel areas that serve as important refuge and rearing areas for fish. Previously, juvenile salmon and steelhead could access the delta during high water in April through June, but were trapped and perished when the water receded. Both projects also would plant native trees and shrubs and place large logs and root wads in wetted areas to provide cover for fish. The projects are a partnership between the U.S. Forest Service, the Oregon Parks and Recreation Department, and the Lower Columbia Estuary Partnership.

3.6. Wildlife

The Columbia white-tailed deer (*Odocoileus virginianus leucurus*) is listed as endangered, but is not found in the Sandy River Basin (USFWS 2012a). The northern spotted owl (*Strix occidentalis caurina*) is listed as threatened and is present in the Sandy River Basin; its range is limited to the protected areas of the Bull Run River watershed, wilderness areas, and the upper reaches of the Salmon River outside semi-rural areas (USFWS 2011b). Federal candidate species include the North American wolverine (*Gulo gulo luscus*) and the streaked horned lark (*Eremophila alpestris strigata*). None of the candidate species are currently known to occur in

the action area (USFWS 2012b; 2012a). Wolverines are rare, with only a few being spotted in Oregon since 1920. Wolverines are found in high-elevation forests in the high Cascades – if they occur in the Sandy River Basin, they would be restricted to the upper reaches of the Sandy River Basin outside semi-rural areas (USFWS 2012b).

Human activities, such as wildlife viewing, hiking, camping, fishing, and other shore-based activities (inside and outside the riparian areas), can impact wildlife through physical contact, disruption of habitat, or avoidance of areas where human activity is high. These types of human activities are common in the action area due to the close proximity to the major metropolitan population areas (Subsection 3.7, Socioeconomics; Subsection 3.8, Tourism and Recreation). Similarly, activities associated with the placement and maintenance of weirs, such as those in the Bull Run River, Zigzag River, and Salmon River, may disrupt wildlife habitat and increase avoidance of areas around the weirs (see Subsection 2.1.1, Sandy River Spring Chinook Salmon Program).

Within the action area, fish are an important part of the diets of a variety of wildlife species including birds and mammals, though none of these are wholly dependent on salmon or steelhead for survival. During salmonid freshwater rearing, various species of wildlife may consume eggs, juveniles, adults, and carcasses from both natural-origin and hatchery-origin salmon and steelhead (Cederholm et al. 1999; Helfield and Naiman 2001).

3.7. Socioeconomics

Prior to contact with European settlers, native peoples harvested fish from the Sandy and Columbia Rivers and hunted elk, deer, bear, and waterfowl. Salmon are culturally, economically, and symbolically important to the Pacific Northwest. Historically, natural resources have been the mainstay of the economies of the Native Americans in the Columbia Basin. Salmon were an important aspect of the cultural life and subsistence of the Indian tribes that occupied the Columbia Basin. Hunting, fishing, and gathering have been important to tribes for thousands of years. With settlement of the area by Europeans, then development of the area through the present day, salmon and steelhead fishing in the Sandy River, as well as other pursuits such as hunting, has become a popular recreational activity for the local and non-local inhabitants of the Portland Metropolitan Area.

The Sandy River flows through two counties, Multnomah and Clackamas Counties in Oregon. The Sandy River is within 50 miles of the top three most-populous counties in Oregon, and these counties make up what is referred to as the Portland Metropolitan Area (Table 7). The populations in these counties are predominantly white and have relatively small Hispanic populations (with the exception of Washington County) and Native American populations (U.S. Census Bureau 2014b) (Table 7).

Table 7. Demographic information regarding counties in the action area (U.S. Census Bureau 2014b).

County	Population (2005)	Percent Hispanic Origin (percent)	Percent Native American (percent)
Multnomah	737,110	10.8	1.0
Clackamas	377,206	7.7	0.7
Washington	531,818	15.6	1.8

The median family income in these counties is higher than the median income for the state. The 2009 median family income in Multnomah County was $62,435, in Clackamas County it was $74,700, and in Washington County it was $76,321; the statewide median family income was $60,025 in Oregon (U.S. Census Bureau 2014b). Dean Runyan Associates (2009) found that, for Oregon resident anglers, 13.4 percent had household incomes less than $25,000, 27.6 percent had incomes from $25,000 to $49,999, 25.5 percent had incomes from $50,000 to $74,999, and 33.5 percent had incomes greater than $75,000.

The annual state budget for the Sandy Hatchery for on-station broodstock collection and rearing is $285,000; it is unknown how much of this is spent within the action area, but the total includes funding for three full-time ODFW employees that live at the hatchery. These employees would have expenditures in the local economy for food, clothing, household items, and for services. The hatcheries would also have hatchery-related expenditures (e.g., equipment, maintenance, feed, chemicals) that support local businesses in the action area.

Recreational activities that may be related to salmon and steelhead fishing are discussed in Subsection 3.7, Tourism and Recreation, because they represent an important recreational activity. However, recreational fisheries are considered here because they represent the largest impact on socioeconomics resulting from the alternatives.

Recreational fisheries support economic activities throughout the state of Oregon and in the action area. The economic impacts and effort of freshwater recreational fisheries statewide can be found in Dean Runyan Associates (2009). In 2011, Oregon residents and nonresidents made three distinct types of fish and wildlife recreation expenditures: (a) trip-related, (b) equipment (including boats and recreational vehicles), and (c) other purchases (USFWS 2011a). When all three categories are combined, the fishing and hunting expenditures were $956 million and wildlife-related expenditures were $2.6 billion in 2011 (USFWS 2011a).

Socioeconomic numbers are not available specifically for the Sandy River Basin, but clear estimations can be made by looking at the economics of hatchery fish and fishery activities connected with hatcheries in the area that includes the Sandy River. Local recreation expenditures occur most notably in travel regions with large urban-centered populations (Willamette Valley, Portland Metropolitan/Columbia, and Southern Oregon), with fishing, hunting, and wildlife viewing representing the bulk of all local recreation expenditures made throughout the state (Table 8). The Sandy Hatchery programs are now funded by the State of Oregon, but in the past they were funded through Mitchell Act funds at levels currently described under the Proposed Action. Mitchell Act funds currently support other hatchery programs at

facilities that also rear salmon and steelhead for programs under the alternatives. Wegge (2010) conducted an economic analysis of Mitchell Act-funded hatchery production (which included the Sandy Hatchery programs) and found that recreational fisheries for Mitchell Act-funded hatchery fish led to expenditures in the Lower Columbia River of over $9.2 million, a direct and secondary economic impact on income in the Lower Columbia River of almost $17.3 million, and contributed to an estimated 395 jobs.

Oregon residents and nonresidents who traveled overnight and on day trips of 50 or more miles (one-way) from home, made travel-generated expenditures of $862 million (Dean Runyan Associates 2009). Local (trips within 50 miles of home) recreation fishing expenditures for the Portland Metropolitan Area totaled $20.5 million (Table 8)(Dean Runyan Associates 2009)). It is unknown how this total is distributed within the local economy, but it might be similar to those who travel to go fishing except for the reduced need for accommodations. Local expenditures include food and beverage services, food stores, ground transportation (fuel), retail purchases, outfitter/guide/charter fees, and equipment (Dean Runyan Associates 2009). All of these expenditures would be expected to support local businesses, but it is unknown how dependent these businesses are on fishing-related expenditures.

Table 8. Expenditures by activity by county, 2008 (in thousands of dollars) (Dean Runyan Associates 2009).

County	Freshwater Fishing ($000)	Hunting ($000)	Wildlife Viewing ($000)
Travel			
Multnomah	7,955	3,387	31,511
Clackamas	7,158	4,421	21,632
Washington	4,816	3,727	15,226
Subtotal	19,929	11,535	68,369
Local Recreation			
Multnomah	8,215	2,662	3,835
Clackamas	8,704	2,496	621
Washington	3,584	1,489	796
Subtotal	20,503	6,647	5,252
Total	**$40,432**	**$18,182**	**$73,621**

In 2008, the economic impact directly associated with freshwater fishing that included the Sandy River Basin was over $40 million (total includes travel and local recreation expenditures) (Table 8) (Dean Runyan Associates 2009); this is primarily due to the basin being adjacent to and within the three highest populated counties in Oregon. The economic impact can also be explained by the high level of catch observed for the Sandy River Basin. ODFW recreational harvest records indicate that the Sandy River Basin has the highest catch rate for hatchery winter steelhead for all of the Columbia River tributaries in Oregon (ODFW 2008; 2009; 2010b; 2011e; 2012). The recreational catch card data show that the Sandy River consistently ranks in the top five streams for spring Chinook salmon harvest and is second only to the Clackamas River Basin for coho salmon harvest. The recreational harvest in the Sandy River has averaged 630 spring Chinook salmon, 3,593 coho salmon, 1,542 winter steelhead, and 680 summer steelhead over the past 5

years (Table 9). The sport catch in the Sandy River has been declining due to reductions in hatchery releases, particularly for coho salmon and spring Chinook salmon.

Table 9. Sandy River recreational harvest from angler catch records (ODFW 2008; 2009; 2010b; 2011e; 2012).

Year	Spring Chinook	Coho	Winter Steelhead	Summer Steelhead
2008	720	7001	1655	950
2009	266	5171	1702	593
2010	693	3952	1589	699
2011	899	1571	533	332
2012	572	272	2230	825
Mean	630	3593	1542	680

The cost of being able to fish legally in Oregon in 2014 is described in (ODFW 2014). The maximum cost to participate in the salmon or steelhead fishery in the Sandy River would occur if a person bought an annual license and adult tag (for salmon and steelhead), which allows the person to fish in all Oregon rivers and lakes (Table 10) – the total annual cost for adult Oregon residents would be $69.25, and for adult non-residents, $132.25. The cost of fishing gear and tackle generally exceed the cost of the fishing license. Recreational anglers buy fishing licenses, which support fishery management and law enforcement activities. Anglers also pay a Federal excise tax on fishing gear, which is returned to the states to support fisheries research, development, and public information actions (ODFW 2014).

Several hundred anglers have participated in the Sandy River fishery each year. In addition, there are employment opportunities in the sector that supports such tourism and recreational services, or the government sector that employs recreational fishery-related staff.

Table 10. Oregon resident annual costs for licenses in 2014 (ODFW 2014).

Angler Age Class	Annual Angling License ($)	Cost of Hatchery Harvest (tag) ($)	Total Cost to Participate In Fishery ($)
Adult (Resident: 18 years of age and older) license	42.75	26.50	69.25
Adult (Non-Resident: 18 years of age and older) license	106.25	26.50	132.75
Juvenile (14 to 17 years of age)	18.75	8.50	26.75

3.8. Tourism and Recreation

Recreational activities in the Sandy River Basin include fishing, river rafting and kayaking, boating, hiking, hunting, picnicking, camping, and non-consumptive observation of wildlife and scenery (NMFS 2008b). There are numerous parks and campgrounds along the river as well. Table 11 summarizes popular recreation sites and dominant recreational uses in the Sandy River Basin (NMFS 2008b).

Fisheries in the Sandy River Basin supported by the hatchery programs were addressed in Subsection 3.7, Socioeconomics; however, the fisheries in the Sandy River targeting hatchery produced fish are only a small part of the larger suite of outdoor recreational activities available to Oregon residents and non-residents. In 2008, nearly 2.8 million Oregon residents and non-residents participated in fishing, hunting, wildlife viewing, and shellfish harvesting in Oregon. Of the total number of participants state-wide, 631,000 fished, 282,000 hunted, 175,000 harvested shellfish, and 1.7 million participated in outdoor recreation where wildlife viewing was a planned activity. Local recreation expenditures of $147 million were made by Oregon residents while participating in these activities within 50 miles of their homes (Dean Runyan Associates 2009). State residents and non-residents also spent an additional $1.5 billion on specialty equipment and other activity-related purchases from retail establishments and suppliers based in Oregon (Dean Runyan Associates 2009).

During 2008, travel-generated expenditures for fishing, hunting, wildlife viewing, and shellfish harvesting activities amounted to over $100 million in each of four of Oregon's eight travel regions (North Coast - $136 million, Central Coast - $126 million, Central - $110 million, and Eastern - $106 million) (Dean Runyan Associates 2009). The Sandy River Basin spans the Portland Metropolitan/Columbia and Mt. Hood Gorge regions; these two regions had a combined $132.7 million in travel-generated expenditures (Dean Runyan Associates 2009). In all nine travel regions, travel-generated expenditures for wildlife viewing and fishing exceeded $462

million and $264 million, respectively (Dean Runyan Associates 2009). While travel-generated expenditures for hunting occurred in each of the nine travel regions of the state, spending in the Eastern, Southern, and Willamette Valley travel regions accounted for nearly two-thirds of the total expenditures related to travel for hunting (Dean Runyan Associates 2009). Local recreation expenditures occurred most notably in travel regions with large urban-centered populations (Willamette Valley, Portland Metropolitan/Columbia, and Southern), with fishing, hunting, and wildlife viewing representing the bulk of all local recreation expenditures made throughout the state (Table 8).

Table 11. Dominant recreational uses in the Sandy River Basin (NMFS 2008b).

Basin Area	Dominant Recreational Uses	Popular Recreation Sites
Upper Sandy River	Hiking, fishing, developed site and dispersed camping, cross-country skiing, nature study, sightseeing, canoeing, kayaking, drift boating, and rafting	McNeal Campground, Riley Horse Camp, and Lost Creek Campground; trails (Top Spur, Pacific Crest, Bald Mountain, Ramona Falls, Yocum Ridge, Paradise Park Loop, Zigzag Mountain, Burnt Lake, Cast Creek, Horseshoe Creek, Sandy River, and McIntyre Ridge)
Middle Sandy River	Boating, fishing, picnicking, swimming, youth camps	Dodge Park, Barlow Trail County Park, Oral Hill Picnic Area, Camp Namanu
Lower Sandy River	Tube rafting, boating, fishing, picnicking, hiking, swimming, youth camps	Oxbow County Park, Dabney State Park, Lewis and Clark State Park, Camp Collins
Salmon River	Camping, fishing, hiking, snowmobiling, skiing, biking, and hunting	Trails (Old Salmon River Trail No. 742B and lower 2 mile of the Salmon River Trail No. 742), Timberline Lodge Area, Trillium Lake and Campground, Green Canyon Campground, Wildwood Recreation Site, Palmer Snowfield (provides year around skiing), Resort at the Mountain, Mt. Hood RV Village, bed and breakfast facilities, residential youth camps
Bull Run River	Fishing, swimming, kayaking below county bridge	Dodge Park (at mouth of river). No recreational use is permitted within the Bull Run Management Area.
Zigzag River	Nordic and alpine skiing, camping, hiking, biking, and sightseeing	Ski areas (Timberline Summit, and Ski Bowl), National Forest Campgrounds (Still Creek, Camp Creek, and Tollgate), six "organization camps," trails (Mirror Lake, the "mountaineering trail" above Timberline Lodge, Pacific Crest Trail, Pioneer Bridle Trail, Hunchback Trail from Kinzel Lake to Devils Peak, Little Zigzag Falls Trail, Camptown and Crosstown trails, and Burnt Lake, Paradise Park,,and Hidden Lake Trails)

3.9. Environmental Justice

Executive Order 12898 (59 FR 7629) states that Federal agencies shall identify and address, as appropriate "…disproportionately high and adverse human health or environmental effects of [their] programs, policies and activities on minority populations and low-income populations…." While there are many economic, social, and cultural elements that influence the viability and location of such populations and their communities, certainly the development, implementation

and enforcement of environmental laws, regulations, and policies can have impacts. Therefore, Federal agencies, including NMFS, must ensure fair treatment, equal protection, and meaningful involvement for minority populations and low-income populations as they develop and apply the laws under their jurisdiction.

In the action area and the Portland Metropolitan Area, there are minority and low-income populations to which this Executive Order could apply. The U.S. Census Bureau reported the race composition of the counties in 2008 to 2012 (U.S. Census Bureau 2014a) to be 77 to 89 percent White, 7 to16 percent Hispanic, 3 to 9 percent Asian, 1 to 6 percent Black or African American, and 1 to 2 percent Native American (Table 12). The composition of the angling public in Oregon (as reported in USFWS (2011a) did not reflect participation by minority groups proportional to race composition in Portland Metropolitan Area. This was likely due to a small sample size for minority respondents to the survey and, given the likelihood that all ethnic groups do engage in recreational fishing, their representation is likely in proportion to their representation in the general population in the Portland Metropolitan Area. This representation may not hold for the Sandy River; access to the Sandy River would be expected to limit participation by these groups because only the lower few miles of the basin are accessible by public transportation. The Sandy River is also not the only area providing fishing opportunity in the Portland Metropolitan Area, and some other areas – such as the Clackamas River and the mainstem Columbia River – may be closer for lower-income residents, based on where in the area they live.

Dean Runyan Associates (2009) estimated that 13.4 percent of the resident anglers in Oregon had incomes less than $25,000 and that 27.6 percent of the anglers had incomes between $25,000 and $49,999.

Table 12. Ethnic composition of Multnomah, Clackamas, and Washington Counties (U.S. Census Bureau 2014a).

County	Race				
	White (%)	**Hispanic or Latin (%)**	**Native American or Alaskan Native (%)**	**Black or African-American (%)**	**Asian (%)**
Multnomah	78.5	10.8	1.0	5.7	6.6
Clackamas	89.9	7.7	0.7	0.8	3.6
Washington	76.9	15.6	1.7	1.8	8.8
All Oregon	85.3	11.7	1.4	1.8	3.7

4. ENVIRONMENTAL CONSEQUENCES

4.1. Introduction

Resources that could be impacted by the alternative actions are described in Section 3, Affected Environment. This section provides analyses of the potential effects of the alternative actions on

those resources within the action area (Subsection1.4, Analysis Area). Note that the analyses in this section use the terms “effects” and “impacts” synonymously (see 40 CFR 1508.8(b)).

4.2. Effects on Water Quality and Water Quantity

4.2.1. Alternative 1 (No-action). Continue to Operate the Four Hatchery Programs as Described and Approved in the 2012 Biological Opinion

As described in Subsection 3.2, Water Quality and Water Quantity, the minor impacts on water quality and water quantity from the continued operation of Sandy Hatchery under the No-action Alternative would continue primarily in the areas of water temperature, turbidity, available dissolved oxygen, and availability of nutrients.

The analysis completed by ODFW in 2006 to comply with the NPDES permit found that the operation of the Sandy Hatchery, even during the months of July and August, only marginally increase the ambient temperature of Cedar Creek in the mixing zone below the hatchery outfall. Under the No-action Alternative, the hatchery would be operated during the summer months and would not be expected to increase thermal loads in Cedar Creek during that time, as described in Subsection 3.2, Water Quality and Water Quantity. It is likely that the two Clean Water Act 303(d) temperature criteria that were exceeded, as described in Subsection 3.1, Water Quality and Water Quantity, would continue to be exceeded. Dissolved oxygen was not identified as a factor limiting water quality (Oregon Department of Environmental Quality 2006). Regardless, dissolved oxygen levels would be expected to remain the same under the No-action Alternative because the dissolved oxygen levels in the hatchery effluent would be restored to ambient levels due to mixing of the hatchery effluent water and water in the adult fish ladder prior to release into Cedar Creek.

The No-action Alternative is likely to have only minor effects on turbidity. To meet the NPDES permit standards for sediment (e.g., total suspended solids and settleable solids), ODFW proposes to continue to treat hatchery effluents in a pollution abatement pond before effluent is discharged into Cedar Creek (Oregon Department of Environmental Quality 2006). The abatement pond would be used to settle out fish waste and fish food solids to prevent release of sediment into Cedar Creek. The Sandy Hatchery would continue to operate under its NPDES permit and it is not expected that the continuation of this permit would have any impact on ODEQ’s issuance of other NPDES permits in the Sandy River Basin. The hatchery effluent may contain aquaculture drugs and chemicals (e.g., formalin), that may impact fish present in Cedar Creek downstream from the hatchery outfall. These impacts are expected to be minor because these drugs are strictly monitored and are prescribed by licensed veterinarians to be effective in the treatment of the fish pathogen while meeting drug label criteria for environmental exposure.

The No-action Alternative would affect water quantity over a short distance. The Sandy Hatchery would use water from Cedar Creek to collect and hold adults and to rear juveniles. During the spring, when acclimating and releasing juvenile fish on station, the hatchery removes up to 11,200 gpm (out of ODFW’s 12,577 gpm water right). A minimum flow of 2,245 gpm would be maintained in the channel to ensure effective upstream migration.

During August and September, rearing of coho salmon at the Sandy Hatchery would require a minimum water withdrawal from Cedar Creek of 2,200 gpm through August and 2,300 gpm through September. Water withdrawals are not expected to have an adverse impact on passage conditions in August, but low flows can occur during September. These withdrawals would be expected to leave between 1,300-1,400 gpm in Cedar Creek to provide for juvenile rearing and passage flows in the by-pass section. The removal of water at the intake would affect water quantity by reducing flow in the 900 feet of stream between the intake structure and the Sandy Hatchery adult holding pond outfall. Minimum flow (at least 1,000 gpm, or 2.3 cfs) would be maintained in this section to allow for juvenile passage between the adult weir and intake structure. However, water quantity would be reduced to a degree that could reduce or prevent adult upstream passage through this section of the stream because natural flows in Cedar Creek are at a minimum during September. Impacts to natural-origin coho salmon would be minimal because all coho salmon migrating up Cedar Creek would be directed into the adult holding pond. Natural-origin coho salmon would be transported and released above the bypass section to continue their migration. Flows in Cedar Creek would remain low until fall rains increase flows, at which point any flow-related impediment to adult passage would be removed and natural-origin adults would be released directly above the adult weir at the hatchery outfall.

Under the No-action Alternative, the 450 to 600 gallons of water per minute withdrawn for the Bull Run acclimation pond would not be expected to impact the flows within the Bull Run River because spring Chinook salmon would be acclimated in mid-March when flows in the Bull Run River are very high (NMFS 2008b) water used in the acclimation pond would return to the same pool, affecting only a small area of the river. Impacts of the acclimation pond on water quality and quantity would be expected to be minimal, because only a small number of juveniles would be reared, and the outfall water would be released into the same pool as the water intake. Under the No-action Alternative, minor impacts on water quality from the feeding of spring Chinook salmon during acclimation would be for a short time during rearing and would not reach levels requiring a NPDES permit.

The No-action Alternative is expected to result in the continued availability of marine-derived nutrients as hatchery salmon and steelhead return to the Sandy River Basin. The continuation of the hatchery programs under the No-action Alternative would result in the annual escapement of adult hatchery salmon and steelhead to the Sandy River Basin being similar to what has been observed recently. The proportion hatchery adults spawning in the wild would be expected to be reduced over the long term through their removal at weirs and traps (e.g., Bull Run River weir) and through fisheries that target adults returning to the hatchery and to the Bull Run River acclimation site. The actual level of marine-derived nutrients is not expected to decline as a result of removal of hatchery-origin returns because hatchery carcasses would be available for outplanting into the upper basin.

Other human activities described in Subsection 3.2, Water Quality and Water Quantity, would continue to contribute to a decline in water quality parameters in the action area under the No-action Alternative.

4.2.2. Alternative 2 (No Hatchery) – Do Not Approve the HGMPs under Limit 5 of the 4(d) Rule

The absence of the hatchery programs under the No-hatchery Alternative would eliminate any effects on water quality in Cedar Creek resulting from the Sandy Hatchery effluent, and on instream flows (water quantity) that were identified in Subsection 3.2, Water Quality and Water Quantity. The actual effect on water temperature would be expected to be minor because the hatchery, when in operation, does not add to the thermal load on Cedar Creek's ambient water temperatures. Because of this, for example, the two Clean Water Act temperature criteria that would be exceeded under the No-action Alternative (Subsection 3.2, Water Quality and Water Quantity) would likely still be exceeded in the absence of the hatchery programs, especially during the summer, low flow months, so the same degree of impairment under section 303(d) of the Clean Water Act would occur under the No-hatchery Alternative. Dissolved oxygen was not identified as a factor limiting water quality (ODEQ 2006), and, as under the No-action Alternative, levels would not be expected to change under the No-hatchery Alternative.

Under the No-hatchery Alternative, because the facility would not be operated, no effluent would be released. However, levels of total suspended solids and settleable solids (turbidity) under the No-action Alternative would already be minor, due to the current use of a pollution abatement pond at the Sandy Hatchery that minimizes turbidity in Cedar Creek due to fish wastes and un-eaten fish food, and thus the No-hatchery Alternative would not result in any great reduction in turbidity compared to the No-action Alternative.

The current NPDES permit for the Sandy Hatchery would not be needed under the No-hatchery Alternative and, as under the No-action Alternative, would still not be expected to have an effect on the number or types of NPDES permits that ODEQ would issue for the Sandy River Basin.

The lack of hatchery programs under the No-hatchery Alternative would mean that the intake structure and adult weir would not be operated. Water that would be removed under the No-action Alternative would remain in Cedar Creek under the No-hatchery Alternative, resulting in higher flows in the bypass section than under the No-action Alternative. The retention of water in Cedar Creek under the No-hatchery Alternative would increase rearing and migration flows in the 900-foot bypass section compared to the No-action Alternative – in particular, this could be a benefit to upstream-migrating salmonids during September, when flows are typically low, and halting water withdrawals for hatchery operation would nearly triple the amount of water flowing through the bypass section in some years under the No-action Alternative. Under the No-hatchery Alternative, the Bull Run acclimation pond would not be operated and, thus, would not have an impact on water quantity or water quality in the Bull Run River. The difference between the No-hatchery Alternative and the No-action Alternative would not be noticeable because flows (water quantity) and water quality are not affected by the operation of the Bull Run acclimation pond.

The exposure to aquaculture drugs and chemicals that would occur under the No-action Alternative would not occur under the No-hatchery Alternative because the hatchery programs would not be operated.

The absence of hatchery fish returning to the basin under the No-hatchery Alternative would be detrimental to the level of marine-derived nutrients in the short-term and possibly beneficial in the long-term. Unlike under the No-action Alternative, the No-hatchery Alternative would essentially eliminate the contribution of hatchery fish carcasses – whether from adults returning to natural spawning and rearing areas or from the outplanting of carcasses – and their associated marine-derived nutrients over the near term; over the long term, the availability of natural-origin carcasses would depend on whether natural populations increase. The amount of marine-derived nutrients under the No-hatchery Alternative would ultimately depend on the abundance of the natural populations. The effects on the overall ecosystem (e.g., aquatic productivity, riparian forests, large woody debris) of reducing the number of hatchery fish would be detrimental until and unless production of natural-origin salmon and steelhead adults exceeds the current level of hatchery and natural-origin adults on the spawning grounds.

Some nutrients from outplanted carcasses could come from other hatcheries, but concerns with disease transmission may prevent the outplanting of carcasses from other basins. It is not certain if a gain in marine-derived nutrients from natural-origin returns would yield measurable beneficial effects given habitat changes due to the other human activities, such as agricultural practices, logging, irrigation, pollution, dams, and urban and industrial development that are unrelated to the proposed hatchery programs but that would continue to affect water quality in the action area.

As under the No-action Alternative, other human activities described in Subsection 3.2, Water Quality and Water Quantity, would continue to contribute to a decline in water quality parameters in the action area under the No-hatchery Alternative.

4.2.3. Alternative 3 (Reduced Production) – Production Limited to Levels that would Achieve less-than-5 Percent pHOS Goal

Under the Reduced Production Alternative, the Sandy Hatchery and Bull Run acclimation pond would be operated as described for the No-action Alternative and, thus, the water quality and quantity impacts would be similar to those under the No-action Alternative. As under the No-action Alternative, the hatchery would be operated during the summer months and would not be expected to increase thermal loads in Cedar Creek during that time. However, under the Reduced Production Alternative, the number of smolts reared at the Sandy Hatchery would be less than under the No-action Alternative (Table 2). The reduced production would not require as much food as under the No-action Alternative and, thus, effects on water quality would be smaller. Furthermore, the reduced production levels would require fewer raceways to rear the production and, therefore, the demand for water from Cedar Creek would be reduced, providing more flow between the intake and the hatchery outfall than under the No-action Alternative.

Under the Reduced Production Alternative, approximately the same amount of water as under the No-action Alternative could be used to reduce the density of the hatchery fish in the hatchery (by using the same number of raceways and, therefore, reducing the number of juveniles per

raceway). Decreasing the density of the fish being reared can be used to improve hatchery smolt survival, which would contribute to the success of the hatchery program.

As under the No-action Alternative, under the Reduced Production Alternative, the hatchery effluent may contain aquaculture drugs and chemicals (formalin) that may impact fish present in Cedar Creek downstream from the hatchery outfall. These drugs would still be prescribed by licensed veterinarians, but the amount of drugs that would be needed under the Reduced Production Alternative (and, therefore, the amount that might be released into the environment) would be expected to be smaller than under the No-action Alternative because fewer fish would be reared.

Under the Reduced Production Alternative, the amount of marine-derived nutrients from returning hatchery fish would be expected to decline compared to the No-action Alternative because the fewer hatchery smolts released would mean fewer adults returning to the basin. For comparison purposes, assuming that 1 percent of the smolts released survive to return as adults and half of those are caught in commercial and recreational fisheries, under the No-action Alternative, up to 5,175 hatchery adults could return to the hatchery and/or spawn naturally. Under the Reduced Production Alternative, assuming the same survival and catch rates, up to 1,560 adults would return, or a 70 percent reduction in the number of hatchery adults that could provide marine-derived nutrients to the ecosystem. As with the No-hatchery Alternative, and in combination with habitat changes due to the other human activities, such as agricultural practices, logging, irrigation, pollution, dams, and urban and industrial development, that are unrelated to the proposed hatchery programs, this reduction could be ameliorated if the natural-origin populations respond to the lower pHOS levels and their abundance increases.

As under the No-action Alternative, other human activities described in Subsection 3.2, Water Quality and Water Quantity, would continue to contribute to a decline in water quality parameters in the action area under the Reduced Production Alternative.

4.2.4. Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule

Under the Proposed Action Alternative, the Sandy Hatchery and Bull Run acclimation pond would be operated as described under the No-action Alternative and, thus, the water quality and quantity impacts would be similar to those under the No-action Alternative. However, under the Proposed Action Alternative, the number of smolts reared at the Sandy Hatchery would be less than under the No-action Alternative, but more than the No-hatchery Alternative and Reduced Production Alternative (Table 2). The effect on water quality (i.e., temperature, 303(d) listings, dissolved oxygen, and availability of nutrients) and quantity would be intermediate between these two alternatives, but would be more similar to the No-action Alternative because the number of juveniles releases under the Proposed Action Alternative would be the same except for coho salmon production, which would be reduced by 40 percent (this assumes that the spring Chinook salmon program ultimately increases to 300,000 smolts).

Under the Proposed Action Alternative, the number of hatchery adults returning to the Sandy River Basin would be expected to be lower than what would be expected for the No-action Alternative, due to the 40 percent reduction in the number of coho salmon smolts released.

However, under the Proposed Action Alternative, the total number of adults delivering marine-derived nutrients to the ecosystem could be greater than under the No-action Alternative if the natural spawning populations increase in abundance due to the effects of the hatchery changes under the Proposed Action Alternative. Under the Proposed Action Alternative, the number of hatchery adults returning marine-derived nutrients to the ecosystem would be lower in the near term than either the Reduced Production Alternative or the No-hatchery Alternative, but potentially larger over the long term if the deficit under those two alternatives could be made up by increases in the abundance of natural-origin salmon and steelhead. However, it is not certain if this gain in marine-derived nutrients would yield measurable beneficial effects given habitat changes due to the other human activities, such as agricultural practices, logging, irrigation, pollution, dams, and urban and industrial development, that are unrelated to the proposed hatchery programs, but that would continue to affect water quality in the action area.

As under the No-action Alternative, other human activities described in Subsection 3.2, Water Quality and Water Quantity, would continue to contribute to a decline in water quality parameters in the action area under the Proposed Action Alternative.

4.3. Effects on Anadromous Fish Listed under the ESA

Anticipated changes in fish resources conditions compared to the affected environment are analyzed by identified risks to listed fish related to hatchery program operations. As such, effects on anadromous fish listed under the ESA are analyzed in comparison to affected environment information provided in Subsection 3.3, Anadromous Fish Listed Under the ESA.

Potential Hatchery Effects

Hatchery programs can affect hatchery-origin or natural-origin salmon and steelhead in a variety of ways. Understanding the general potential effects of hatchery programs assists in developing programs that meet program goals and objectives and in the analyses of potential program effects. The following explanation of the range of effects hatchery programs and their associated facilities may have, in general, on salmon and steelhead is intended to inform the analyses of the specific effects of artificial production in the Sandy River Basin.

A key factor in analyzing a hatchery program for its effects, positive and negative, on the status of salmon and steelhead is the genetic resources that reside in the program. Genetic resources that represent the ecological and genetic diversity of a species can reside in a hatchery program. “Hatchery programs with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU are considered part of the ESU and would be included in any listing of the ESU” (NMFS 2005). NMFS monitors hatchery practices to assess promotion of the conservation of genetic resources included in an ESU or steelhead DPS and updates the status of genetic resources residing in hatchery programs every 5 years. Jones (2011) provides the most recent update of the relatedness of Pacific Northwest hatchery programs to 18 salmon ESUs and steelhead DPSs listed under the ESA. Generally, hatchery programs that are reproductively connected or “integrated” with a natural population, if one still exists, and that promote natural selection over selection in the hatchery, contain genetic resources that represent the ecological and genetic diversity of a species and are included in an ESU or steelhead DPS.

When a hatchery program actively maintains distinctions or promotes differentiation between hatchery fish and fish from a native population, NMFS refers to the program as "segregated" (also used interchangeably as an "isolated" program). Segregated hatchery programs have a level of genetic divergence, relative to the local natural population(s), that is more than what occurs within the ESU and are not considered part of an ESU or steelhead DPS. These programs promote domestication or selection in the hatchery over selection in the wild and select for and culture a stock of fish with different phenotypes. For example, fish from segregated hatchery programs can have different ocean migrations and spatial and temporal spawning distribution than the underlying native population.

When evaluating effects of hatchery actions on salmon and steelhead, NMFS begins its analysis looking at impacts on individual fish and then at how these impacts on individuals of a population affect the factors used to determine VSP parameters for the population (McElhany et al. 2000). NMFS defines population performance measures in terms of natural-origin fish and the four VSP parameters – abundance, productivity, spatial structure, and diversity – and then relates effects of the alternatives at the population scale to the MPG or stratum level and ultimately to the survival and recovery of an entire ESU or DPS (Figure 2).

Artificial propagation may be useful in the recovery of listed salmon species (Hard et al. 1992). The hatchery environment can, for example, circumvent the high rates of mortality that salmon and steelhead typically experience in the wild; if mortality rates during egg incubation or early rearing in the wild are a factor limiting population survival and recovery, the use of a hatchery facility for this portion of the life cycle can outweigh, in the short term, adverse effects of artificial propagation. The degree to which benefits outweigh risks is a key part of the analyses of the Sandy River hatchery programs. Alternatives are analyzed for effects, positive and negative, on the attributes that define population viability, including abundance, productivity, spatial structure, and diversity. The effects of a hatchery program on the status of an ESU or steelhead DPS "will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery fish within the ESU affect each of the attributes" (NMFS 2005). The presence of hatchery fish within the ESU can positively affect the overall status of the ESU by increasing the number of natural spawners, by serving as a source population for repopulating unoccupied habitat and increasing spatial distribution, and by conserving genetic resources. "Conversely, a hatchery program managed without adequate consideration can affect a listing determination by reducing adaptive genetic diversity of the ESU, and by reducing the reproductive fitness and productivity of the ESU" (NMFS 2005). NMFS also analyzes and takes into account the effects of hatchery facilities – for example, weirs and water diversions – on each VSP attribute and on designated critical habitat.

NMFS' analysis of the alternatives reflects effects that each alternative would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available, on the general type of effect of that aspect of hatchery operation in the context of the specific application in the Sandy River. This allows for quantification (wherever possible) of the various factors of hatchery operation to be applied to each applicable life-stage of the listed species at the population level (in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA), which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole.

The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 13. Generally, effects range from beneficial to negative for programs that use local fish[11] for hatchery broodstock and from negligible to negative when a program does not use local fish for broodstock[12]. Hatchery programs can benefit population viability but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS assesses how effective the program would be at isolating hatchery fish and avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. The range in effects for a specific hatchery program are refined and narrowed after available scientific information and the circumstances and conditions that are unique to individual hatchery programs are accounted for.

Analysis of an alternative for its effects on ESA-listed species and on designated critical habitat depends on seven factors. These factors are:

(1) the hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock,
(2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities,
(3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas,
(4) hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean,
(5) Research, Monitoring, and Evaluation (RM&E) that exists because of the hatchery program,
(6) the operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and
(7) fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

The potential effects of these seven factors on natural-origin salmon and steelhead are described in detail below. These seven factors would be used as the basis for analyzing the effects of the different alternatives on the ESA-listed species.

[11] The term "local fish" is defined to mean fish with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU or steelhead DPS (70 FR 37215, June 28, 2005).
[12] Exceptions include restoring extirpated populations and gene banks.

Table 13. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs.

Natural Population Viability Parameter	Hatchery Broodstock Originate from the Local Population and are Included in the ESU or DPS	Hatchery Broodstock Originate from a Non-local Population or from Fish that are not Included in the Same ESU or DPS
Productivity	Hatcheries are unlikely to benefit productivity except in cases where the natural population's small size is, in itself, a predominant factor limiting population growth (i.e., productivity) (NMFS 2004b).	The effect on productivity is dependent on differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the more negligible the affect).
Diversity	Hatcheries can temporarily support natural populations that might otherwise be extirpated or suffer severe bottlenecks and have the potential to increase the effective size of small natural populations. Broodstock collection that homogenizes population structure is a threat to population diversity.	The effect on diversity is dependent on the differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish the greater the threat) and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the more negligible the affect).
Abundance	Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance and productivity of the natural populations in the ESU (70 FR 37204, June 28, 2005, at 37215).	The effect on abundance is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the more negligible the affect), handling, RM&E and facility operation, maintenance and construction effects.
Spatial Structure	Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. "Any benefits to spatial structure over the long term depend on the degree to which the hatchery stock(s) add to (rather than replace) natural populations" (70 FR 37204, June 28, 2005 at 37213).	The effect on spatial structure is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the more negligible the affect).

The category of effect assigned is based on an analysis of each factor weighed (1 through 7, above) against the affected population(s) current risk level for abundance, productivity, spatial structure and diversity, the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery, the target viability for the affected natural population(s), and the environmental baseline including the factors currently limiting population viability. These factors are described below.

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

When evaluating hatchery programs, NMFS considers the risk to a natural population from the removal of natural-origin fish for hatchery broodstock.

A primary consideration in analyzing and assigning effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological pros and cons of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the donor population tapped to provide hatchery broodstock. "Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure. Also considered here is whether the program "backfills" with fish from outside the local or immediate area. The focus of consideration under this factor is the demographic effect of removing fish, including whether a net reduction in abundance results and what the effect of that reduction might be on the natural population. Additional, and possibly larger, repercussions could result from the genetic effects of such removal and injection of other fish – such effects are evaluated under Factor 2 and Factor 3, below. The physical process of collecting hatchery broodstock and the effect of the process on ESA-listed species is considered under Factor 2.

Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

NMFS also analyzes the effects of hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds. There are two aspects to this part of the analysis: genetic effects and ecological effects. Genetic effects on the natural-origin population due to hatchery fish spawning naturally are described next, followed by a description of ecological effects (e.g., competition and predation) resulting from interactions between hatchery and natural-origin juveniles.

NMFS generally views genetic effects as detrimental because, at this time, based on the weight of available scientific information, artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations. Hatchery fish can thus, pose a risk to diversity and to natural population rebuilding and recovery when they interbreed with fish from natural populations.

However, NMFS recognizes that there are benefits as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford 2011). Furthermore, NMFS also recognizes there is considerable debate regarding genetic risk. The extent and duration of genetic change and fitness loss and the short and long-term implications and consequences for different species, for species with multiple life-history types, and for

species subjected to different hatchery practices and protocols remains unclear and should be the subject of further scientific investigation. As a result, NMFS believes that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011b).

Genetic Effects

Hatchery fish can have a variety of genetic effects on natural population productivity and diversity when they interbreed with natural-origin fish. Although there is biological interdependence between them, NMFS considers three major areas of genetic effects of hatchery programs: within-population diversity, outbreeding effects, and hatchery-influenced selection. In most cases, the effects are viewed as risks, but in small populations these effects can sometimes be beneficial, reducing extinction risk.

Within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size (N_e), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (e.g., Lande and Barrowclough 1987), and diversity loss can be severe if N_e drops to a few dozen.

As described above, the hatchery environment can circumvent the high rates of mortality that salmon and steelhead typically experience in the wild; thus, hatchery programs can create more fish than would have existed without the program, potentially increasing N_e. In very small populations this can be a benefit, increasing selection efficiency and reducing other small-population risks (e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). In this way, conservation hatchery programs can serve to protect genetic diversity.

However, hatchery programs can also directly depress N_e by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery. If a substantial proportion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size and, if the operation fails, the effective size of the population would be reduced (Waples and Do 1994). N_e can also be reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling semen is especially problematic because, when semen of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). An extreme form of N_e reduction is the Ryman-Laikre effect (Ryman and Laikre 1991; Ryman et al. 1995), when N_e is reduced as a result of the return to the spawning grounds of large numbers of hatchery fish from very few parents. One way to reduce these effects is by using factorial mating schemes, in which fish are systematically mated multiple times, which can result in increases in N_e.

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

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

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

The proportion of hatchery fish (pHOS) among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before finally spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Saisa

et al. 2003; Blankenship et al. 2007). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Reisenbichler and McIntyre 1977; Leider et al. 1990; McLean et al. 2004; Williamson et al. 2010b).

Hatchery-influenced selection (often called domestication) occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. Hatchery-influenced selection can range from relaxation of selection, that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999).

Genetic change and fitness reduction resulting from hatchery-influenced selection depends on: (1) the difference in selection pressures; (2) the exposure or amount of time the fish spends in the hatchery environment; and, (3) the duration of hatchery program operation (i.e., the number of generations that fish are propagated by the program). On an individual level, exposure time in large part equates to fish culture, both the environment experienced by the fish in the hatchery and natural selection pressures, independent of the hatchery environment. On a population basis, exposure is determined by the proportion of natural-origin fish in the hatchery broodstock and the proportion of natural spawners consisting of hatchery-origin fish (Lynch and O'Hely 2001; Ford 2002), and then by the number of years the exposure takes place. In assessing risk or determining impact, all three levels must be considered. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

Most of the empirical evidence of fitness depression due to hatchery-influenced selection comes from studies of species that are reared in the hatchery environment for an extended period – 1 to 2 years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and Chum salmon is much shorter, just a few months. One steelhead study (Araki et al. 2007; Araki et al. 2008) showed dramatic fitness declines in the progeny of naturally spawning Hood River hatchery steelhead.

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery-origin and natural-origin fish (e.g.,Berntson et al. 2011; Theriault et al. 2011; Ford et al. 2012; Hess et al. 2012b). All of these studies have shown that hatchery-origin fish generally have lower reproductive success, though the differences between hatchery and natural-origin spawners in reproductive success have not always been statistically significant and, in some years, in some studies, hatchery fish have had higher reproductive success than natural-origin fish. Lowered reproductive success of hatchery-origin fish is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection, studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date, only the Hood River steelhead (Araki et al.

2007; Christie et al. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported on multiple-generation effects.

Critical information for analysis of hatchery-influenced selection includes the number, location, and timing of naturally spawning hatchery fish; the estimated level of gene flow between hatchery-origin and natural-origin fish; the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat); the level and intensity of hatchery selection; and the number of years the operation has been run in this particular way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish. The Interior Columbia Technical Recovery Team developed guidelines based on the pHOS (ICTRT 2007b) (Figure 13).

Proportionate Natural Influence (PNI)

More recently, the Hatchery Scientific Review Group (HSRG) developed gene flow criteria/guidelines based on mathematical models developed by Ford (2002) and by Lynch and O'Hely (2001). Guidelines for segregated programs are based on pHOS, but guidelines for integrated programs are also based on a metric called proportionate natural influence (PNI), which is a function of pHOS and pNOB. PNI is in theory a reflection of the relative strength of selection in the hatchery and natural environments: a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the natural population. For a population of high conservation importance, HSRG guidelines are for a pHOS of no greater than 5 percent for segregated programs or a pHOS no greater than 30 percent and PNI of at least 0.67 for integrated programs (HSRG 2009c). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk, in the short-term. HSRG (2004) offered additional guidance regarding segregated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population.

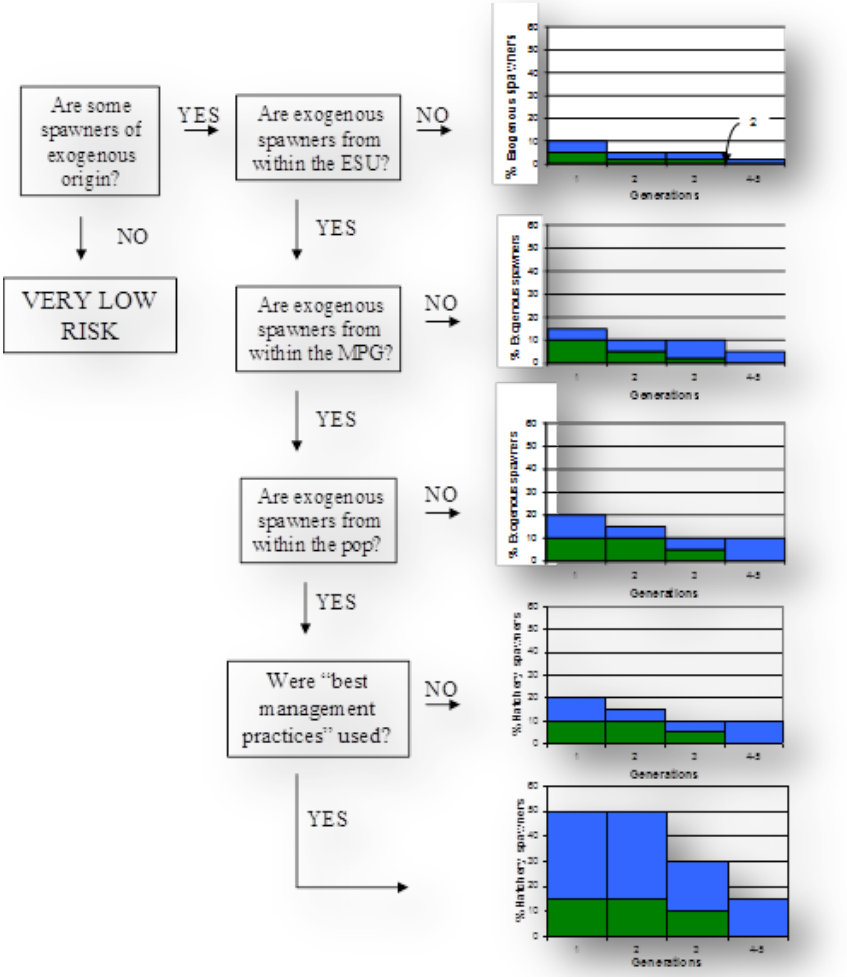

Figure 13. ICTRT (2007b) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Green (darkest) areas indicate low risk combinations of duration and proportion of spawners, blue (intermediate areas indicate moderate risk areas and white areas and areas outside the graphed range indicate high risk). Exogenous fish are considered to be all fish hatchery origin, and non-normative strays of natural origin.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that, while differing considerably from those developed by the earlier group in some ways, re-iterated a pHOS objective of less than 5 percent (California HSRG 2012). The California HSRG felt that truly segregated programs in which no returning hatchery-origin adults interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept. However, if programs were to be managed as segregated, they recommend a pHOS of less than 5 percent. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS would depend upon multiple factors, such as "the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling

opportunity". They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 0.50 in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times. They also recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population.

Building on the work completed by the California HSRG (California HSRG 2012), input from other reviews, and its previous efforts, the HSRG published a report that updated the perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest (HSRG 2014). The report reviewed new information and considered whether the HSRG's principles, broad recommendations, and analytical framework remain consistent with the best available science. HSRG (2014) reaffirmed its standards for programs that are integrated with the natural-origin population: pNOB should exceed pHOS by at least a factor of two, corresponding to a PNI value of 0.67 or greater and pHOS less than 30 percent. In HSRG (2009c) for a *primary* population (one with a goal of high viability), the recommended pHOS level was less than 5 percent; however, the HSRG (2014) observed in a modeling exercise comparing their guidelines for integrated and segregated programs that, at this pHOS level, the relative fitness of the natural-origin population was substantially lower than that observed for a PNI of 0.67 (Table 14)[13]. The HSRG stated that, for segregated programs, the less-than-5 percent pHOS standard may be insufficient to safeguard the long-term viability of the affected natural-origin population, and that segregated hatchery programs should be used with greater caution and require more intensive monitoring (HSRG 2014).

Table 14. Predicted long-term effect on fitness as a function of pHOS and PNI for segregated and integrated hatchery programs (HSRG 2014).

Segregated		Integrated		
			Fitness Factor	
pHOS	Fitness Factor	PNI	pHOS=10%	pHOS=30%
2%	0.85	0.77	0.92	0.91
3%	0.76	0.75	0.91	0.9
4%	0.68	0.71	0.89	0.87
5%	0.62	0.67	0.86	0.83
6%	0.57	0.6	0.81	0.77
10%	0.20	0.5	0.74	0.67

Discussions involving pHOS can be problematic due to variation in its definition. Most commonly, the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report,

[13] NMFS analysis (Busack 2010) shows that relative fitness values achieved by modeling segregated programs depend greatly on assumed selection strengths and heritabilities. Hence, the HSRG results are not absolute.

equating it with "the proportion of the natural spawning population that is made up of hatchery fish" in the Conclusion, Principles and Recommendations section (HSRG 2009c), but with "the proportion of *effective* hatchery origin spawners" in their gene flow criteria. In addition, in their Analytical Methods and Information Sources section (HSRG 2009c, appendix C), they introduce a new term, *effective pHOS*. The difference between pHOS and *effective* pHOS is due to the evidence that indicates that hatchery fish are not as effective as natural-origin fish in their ability to effectively spawn and contribute to the next generation (see discussion of RRS, above). Because hatchery fish are not as effective as natural-origin fish, the genetic effects of hatchery fish spawning naturally may not be as intense as would be indicated by the measured proportion of hatchery fish on the spawning grounds (i.e., pHOS). Despite these inconsistencies, their overall usage of pHOS indicates an intent to use pHOS as a surrogate measure of gene flow potential. This is demonstrated in the fitness effects appendix (HSRG 2009c, appendix A1), in which pHOS is substituted for a gene flow variable in the equations used to develop the criteria.

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

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

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

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

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

NMFS recommends that adjustment of census pHOS by RRS be conducted cautiously, for the following reason. The Ford (2002) model, the foundation of the HSRG gene flow guidelines, implicitly includes a genetic component of RRS. In that model, hatchery fish are expected to have RRS less than 1 (compared to natural fish) due to selection in the hatchery. A component of reduced RRS of hatchery fish is therefore already incorporated into the model and, by extension, the calculation of PNI. Therefore, reducing pHOS values by multiplying by RRS will result in underestimating the relevant pHOS and, therefore, overestimating PNI. Such adjustments would be particularly inappropriate for hatchery programs with low pNOB, as these programs may well have a substantial reduction in RRS due to genetic factors already incorporated into the model.

In some cases, adjusting pHOS downward may be appropriate, particularly if there is strong evidence of a non-genetic component to RRS. An example of a case in which an adjustment by RRS might be justified is that of Wenatchee spring Chinook salmon (Williamson et al. 2010a), where the spatial distribution of natural-origin and hatchery-origin spawners differs, and the hatchery-origin fish tend to spawn in poorer habitat. However, even in this situation, it is unclear

how much of an adjustment would be appropriate. Similarly, it might also be appropriate to adjust the value for pNOB in some circumstances. For example, if hatchery juveniles produced from natural-origin broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs (CITE), the "effective" pNOB might be much lower than the census pNOB.

It is also important to recognize that PNI is only an approximation of relative trait value. To the degree that PNI fails to capture important biological information, it would be better to work to include this information in the underlying models rather than make ad hoc adjustments to a statistic that was only intended to be a rough guideline to managers. Until further PNI clarification is provided, NMFS adopts census pHOS as the appropriate metric to use for genetic risk evaluation.

For that reason, NMFS uses census pHOS when describing management goals for the hatchery programs. For example, the pHOS goal for the spring Chinook salmon program is 10 percent, and this would be measured as the census pHOS (Subsection 2.1.1. Sandy River Spring Chinook Salmon Program). This could provide a conservative estimate of the risk of hatchery-influence effects as the actual effectiveness of the hatchery fish spawning naturally could be less than what would be indicated by census pHOS.

Another factor that could affect non-genetic RRS is described by a simple analysis of the expected proportions of mating types. Figure 14 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the pHOS, assuming that N and H adults mate randomly[14], which is a key assumption of the Ford (2002) model. For example, at the vertical line on the diagram marking the situation at a census pHOS level of 10 percent, expectations are that 81 percent of the matings would be NxN[15], 18 percent would be NxH, and 1 percent would be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10 percent would have an 81 percent chance of having two natural-origin parents, etc.

Random mating assumes that the natural-origin and hatchery-origin spawners overlap completely spatially and temporally. As overlap decreases, the proportion of NxH matings decreases and with no overlap the proportion of NxN matings is (1- pHOS) and the proportion of HxH matings is pHOS. RRS does not affect the mating type proportions directly, but changes their effective proportions. Overlap and RRS can be related. In the Wenatchee River, hatchery spring Chinook salmon tend to spawn lower in the system than natural-origin fish, and this accounts for a

[14] These computations are purely theoretical, based on a simple mathematical binomial expansion ($(a+b)^2=a^2 + 2ab + b^2$, where a is the proportion of natural-origin fish (N), b is the proportion of hatchery fish (H), and the expression $(a+b)^2$ is a term related to the matings between these two groups.

[15] In this document, mating patterns are depicted as NxN (a natural-origin parent mating with another natural-origin parent), NxH (a natural-origin parent mating with a hatchery-origin parent), and HxH (mating between two hatchery-origin parents).

considerable amount of their lowered reproductive success (Williamson et al. 2010a). In that particular situation, the hatchery-origin fish were spawning in inferior habitat.

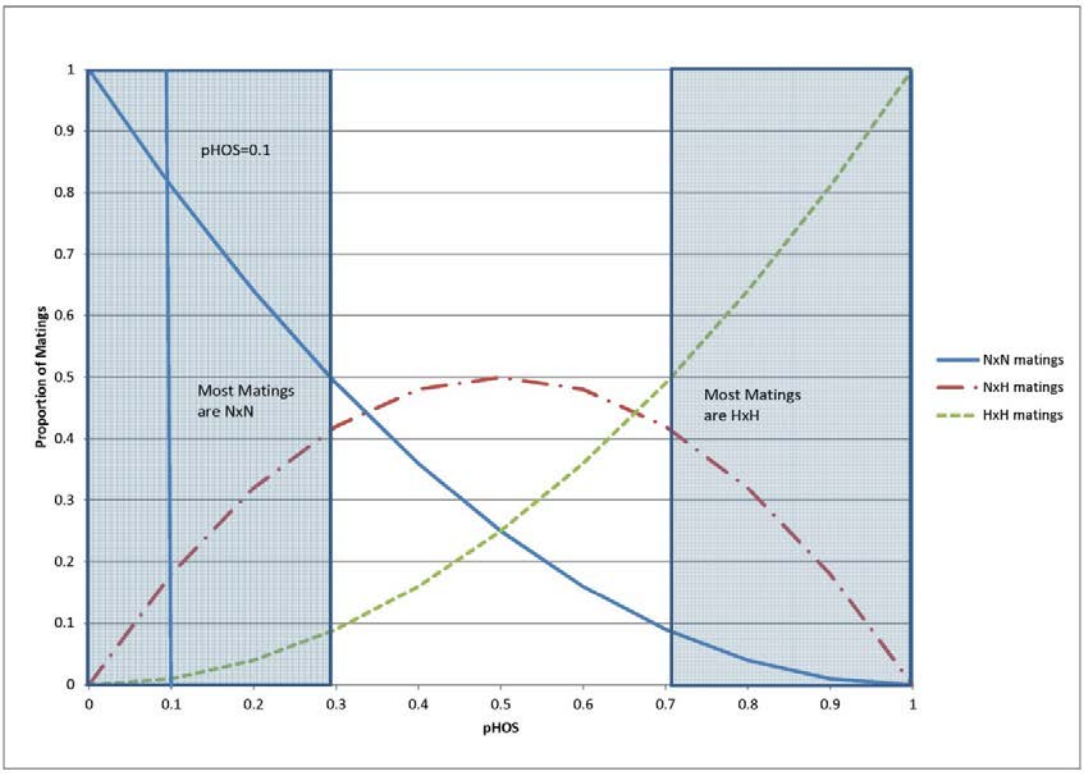

Figure 14. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS) (NxN – natural-origin x natural-origin; NxH – natural-origin x hatchery; HXH – hatchery x hatchery).

Acclimation

One factor the can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners is the acclimation of hatchery juveniles prior to release. Acclimation of hatchery juveniles prior to release increases the probability that hatchery adults would home back (return) to the release location, reducing their potential to stray into natural spawning areas. Dittman and Quinn (2008) provide an extensive literature review and introduction to homing in Pacific Salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2013). Fisheries managers use this innate ability for salmon and steelhead to home to specific streams when using acclimation ponds to support

the reintroduction of species into newly accessible habitat or into areas where they have been extirpated as well as a way to provide for fisheries (Quinn 1997; Dunnigan 2000; YKFP 2008).

Dittman and Quinn (2008) reference numerous experiments that indicate that a critical period for olfactory imprinting (smell) is during the parr-smolt transformation, which is the period when the salmonids go through changes in physiology, morphology, and behavior in preparation for transitioning from fresh water to the ocean (Hoar 1976; Beckman et al. 2000). Salmon species with complex life histories (e.g., sockeye salmon) may imprint at multiple times from emergence to early migration (Dittman et al. 2010). Imprinting to a particular location, be it the hatchery or an acclimation pond, through the acclimation and release of hatchery salmon and steelhead is employed by fisheries managers with the goal that the hatchery fish released from these locations would return to that particular site and not stray into other areas (Fulton and Pearson 1981; Quinn 1997; Hard and Heard 1999; Bentzen et al. 2001; Kostow 2009; Kostow 2012; Westley et al. 2013), although it does not always show a clear benefit (e.g.,Kenaston et al. 2001; Clarke et al. 2011). Acclimating fish for a period of time also allows them to recover from the stress from handling and transporting the fish to the release location.

Having hatchery salmon and steelhead home to a particular location is one measure that can be taken to reduce the proportion of hatchery fish in the naturally spawning population. By having the hatchery fish home to a particular location, those fish can be removed (e.g., through fisheries, use of a weir) or they can be segregated from primary spawning areas. Elements that can affect the success of this measure include the timing of the acclimation such that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation; whether the water source is unique enough to attract returning adults; whether or not the hatchery fish can access the stream reach where they were released; and whether the water quantity and quality is such that returning hatchery fish would hold in that area prior to their removal and/or harvest in fisheries.

Ecological Effects

Ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refer to effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects on the spawning grounds may be positive or negative. To the extent that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Kline et al. 1990; Piorkowski 1995; Larkin and Slaney 1996; Gresh et al. 2000; Murota 2003; Quamme and Slaney 2003; Wipfli et al. 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; Larkin and Slaney 1996; Quinn and Peterson 1996; Bradford et al. 2000; Bell 2001; Brakensiek 2002).

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

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

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

A number of effects can occur as a result of the operation of structures used to collect hatchery broodstock and/or to remove hatchery adults from the river to prevent them from spawning naturally. When analyzing the effects of the structures on the adult and juvenile fish, NMFS reviews effects from weir rejection, fallback, handling related mortality, and delay as well as impacts on riparian habitat, channel morphology, habitat complexity, water flow, and instream substrates attributable to the construction/installation, and operation of the structures.

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

The most important effects considerations under Factor 3 are competition with and predation on natural-origin juvenile fish by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, as well as the premature emigration of natural-origin fish caused by hatchery fish outmigrating *en masse*.

Competition

Generally, competition and a corresponding reduction in productivity and survival may result from direct interactions when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish or through indirect means, when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (SIWG 1984). Naturally produced fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, when

hatchery fish take up residency before naturally produced fry emerge from redds, and if hatchery fish residualize. Hatchery fish might alter naturally produced salmon behavioral patterns and habitat use, making the natural-origin fish more susceptible to predators than if the hatchery fish were not present (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter naturally produced salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on naturally produced fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Specific hazards associated with competitive impacts of hatchery salmonids on listed naturally produced salmonids may include competition for food and rearing sites (NMFS 2012a). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (SIWG 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at “high risk” due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

Several factors influence the risk of competition posed by hatchery releases: whether competition is intra- or interspecific; the duration of freshwater co-occurrence of hatchery and natural-origin fish; relative body sizes of the two groups; prior residence of shared habitat; environmentally induced developmental differences; and, density in shared habitat (Tatara and Berejikian 2012). Intraspecific competition would be expected to be greater than interspecific, and competition would be expected to increase with prolonged freshwater co-occurrence. Although newly released hatchery smolts are commonly larger than natural-origin fish, and larger fish usually are superior competitors, natural-origin fish have the competitive advantage of prior residence when defending territories and resources in shared natural freshwater habitat. Tatara and Berejikian (2012) further reported that hatchery-influenced developmental differences from co-occurring natural-origin fish life stages are variable and can favor both hatchery- and natural-origin fish. They concluded that of all factors, fish density of the composite population in relation to habitat carrying capacity likely exerts the greatest influence. Natural-origin salmon and steelhead do not smolt and migrate toward the ocean all at once – rather, they have a protracted emigration, leaving rearing areas far upstream over the course of several months. This is in contrast to hatchery fish that are relatively uniform in size and behavior and leave the hatchery *en masse*, and likely would spend only hours or days in the river before emigrating towards the Pacific Ocean. This difference in behavior between hatchery and natural-origin juvenile salmonids reduces co-occurrence and the potential for competition.

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 only small-scale displacement of juvenile natural-origin rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and naturally produced juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

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

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

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990; California HSRG 2012).
- Operating hatcheries such that hatchery fish are reared to sufficient size that smoltification occurs in nearly the entire population.
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing by 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 determined likely.

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

Predation

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (direct consumption) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish and by the progeny of naturally spawning hatchery fish and by avian and other predators attracted to the area by an abundance of hatchery fish. Hatchery fish originating

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

Hatchery fish are reared and then released when they are large and ready to leave freshwater. Consequently, they are more likely to migrate quickly to the ocean than smaller, less mature fish (such as natural-origin fish during early rearing). This release pattern substantially reduces the likelihood that hatchery fish would prey on natural-origin fish during some extended freshwater rearing, but hatchery fish could still prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream (residuals) where they can prey on stream-rearing juveniles over a more prolonged period. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance and when spatial structure is already reduced, when habitat – particularly refuge habitat – is limited, and when environmental conditions favor high visibility.

SIWG (1984) rated most risks associated with predation as unknown, because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas. More studies are now available, but they are too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook salmon and steelhead, and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986; Hawkins and Tipping 1999; Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead timing and release protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook 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). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher from naturally produced smolts (coho salmon and cutthroat, predominantly) than their hatchery counterparts.

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (Pearsons and Fritts 1999; HSRG 2004) but other studies have concluded that salmonid predators prey on fish one-third 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).

There are several steps that hatchery programs can implement to reduce or avoid the threat of predation:

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

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

The Proposed Recovery Plan for Snake River Salmon (NMFS 1995) described the issue of what ecological effects large numbers of hatchery releases from multiple programs might have. There is intense debate over the issues of carrying capacity and density-dependent effects on natural populations of salmon. However, there is little definitive information available to directly address the effects of ecological factors on survival and growth in natural populations of Pacific salmon. Thus, many of the ecological consequences of releasing hatchery fish into the wild are poorly defined. The proposed recovery plan called on hatchery operators and funding entities to "limit annual releases of anadromous fishes from Columbia Basin hatcheries," and releases have declined substantially. Hatchery releases for the entire Columbia River Basin now vary between 130 and 145 million fish annually compared to a previous annual production of approximately 200 million fish in the late 1990s.

Based on a review of the scientific literature, NMFS' conclusion is that the influence of density-dependent interactions on the growth and survival of salmon and steelhead is likely minor compared with the effects of large-scale and regional environmental conditions and, while there is evidence that large-scale hatchery production can effect salmon survival at sea, the degree of effect or level of influence is not yet well understood or predictable. The same is true for mainstem rivers and estuaries. NMFS monitors emerging science and information to identify new effects from density-dependent interactions in the migration corridor that may affect listed species or critical habitat in a manner or to an extent not considered in this analysis (50 CFR 402.16).

Factor 5. Research, monitoring, and evaluation (RM&E) that exists because of the hatchery program

NMFS also analyzes proposed RM&E for its effects on listed species and on designated critical habitat.

Generally, negative effects on the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces critical uncertainties. RM&E actions including but not limited to collection and handling (purposeful or inadvertent), holding the fish in captivity, sampling (e.g., the removal of scales and tissues), tagging and fin-clipping, and observation (in-water or from the bank) can cause harmful changes in behavior and reduced survival. These effects should not be confused with handling effects analyzed under broodstock collection. In addition, NMFS also considers the overall effectiveness of the RM&E program.

There are five factors that NMFS takes into account when it assesses the beneficial and adverse effects of hatchery RM&E: (1) the status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat, (2) critical uncertainties over effects of the alternative on the species, (3) performance monitoring and determining the effectiveness of the hatchery program at achieving its goals and objectives, (4) identifying and quantifying collateral effects, and (5) tracking compliance of the hatchery program with the terms and conditions for implementing the program. After assessing the proposed hatchery RM&E and before it makes any recommendations to the action agencies, NMFS considers the benefit or usefulness of new or additional information, whether the desired information is available from another source, the effects on ESA-listed species, and cost.

Hatchery actions also must be assessed for masking effects. For these purposes, masking is when hatchery fish included in the alternative mix with and are not identifiable from other fish. The effect of masking is that it undermines and confuses monitoring, evaluation, and research (ME&R) and status and trends monitoring. Both adult and juvenile hatchery fish can have masking effects. When presented with a proposed hatchery action, NMFS analyzes the nature and level of uncertainties caused by masking and whether and to what extent listed salmon and steelhead are at increased risk. The analysis also takes into account the role of the affected salmon and steelhead population(s) in recovery and whether unidentifiable hatchery fish compromise important ME&R.

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

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles and adults. It can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. When analyzing the effects of construction, operation, and maintenance of hatchery facilities, NMFS reviews changes to riparian habitat, channel morphology and habitat complexity, instream substrates, and water quantity and water quality attributable to operation, maintenance, and construction activities and confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria.

Factor 7. Fisheries that exist because of the hatchery program

Hatcheries can produce fish in excess of what might be needed for conservation and recovery, with the result (usually explicitly intended) that those additional fish can be harvested in

fisheries. Such harvestable fish can, for example, play an important role in fulfilling trust and treaty obligations. There are two aspects of fisheries that are potentially relevant to NMFS' analysis of HGMP effects. One is when fisheries exist because of the HGMP (i.e., the fishery is an interrelated and interdependent action) and listed species are inadvertently and incidentally taken in those fisheries. The other is when fisheries are used as a tool to prevent the hatchery fish associated with the HGMP, including hatchery fish included in an ESA-listed ESU or steelhead DPS, from spawning naturally.

4.3.1. Alternative 1 (No-action) – Continue to Operate the Four Hatchery Programs as Described and Approved in the 2012 Biological Opinion

4.3.1.1. Sandy River Spring Chinook Salmon

Life History

Subsection 3.3.1, Sandy River Spring Chinook Salmon, describes populations that are part of the LCR Chinook Salmon ESU, including the three distinct Chinook salmon populations in the Sandy River (spring, late-fall brights, and early fall tules). None of the Chinook salmon populations outside the action area, nor their associated habitat, would be affected under the No-action Alternative.

The life history characteristics of the three Chinook salmon populations in the Sandy River would not be expected to change under the No-action Alternative. For the tule fall Chinook salmon and late-fall bright Chinook salmon populations, the life-histories would not be expected to change because there would be minimal, if any, effect on these run-types from the current hatchery programs (Subsection 3.3.1, Sandy River Spring Chinook Salmon). The spring Chinook salmon hatchery program may impact the life history characteristics of the natural-origin spring Chinook salmon population, but these impacts are expected to be minimal because the hatchery spring Chinook salmon were part of an integrated hatchery program derived from the natural-origin Sandy River spring Chinook salmon population, and the program has incorporated natural-origin spring Chinook salmon into the broodstock to maintain similarities between the hatchery and natural-origin spring Chinook salmon. However, over the long term, the spring Chinook salmon program under the No-action Alternative would be operated as an segregated hatchery program and, thus, may impact the life history characteristics of the natural-origin spring Chinook salmon population because natural-origin spring Chinook salmon would not be used for broodstock and, therefore, genetic and demographic effects might begin to accrue as a result of the hatchery spring Chinook salmon continuing to interbreed with the natural population.

Status and Trends

The ESA-listing status and risk categories (described in Subsection 3.3.1, Sandy River Spring Chinook Salmon) for the three natural-origin Chinook salmon populations in the Sandy River Basin are not expected to change under the No-action Alternative. Impacts under the No-action Alternative would not be expected to change risk categories for the tule fall Chinook salmon population or the late fall Chinook salmon population because impacts from the hatchery programs would be minor (Subsection 3.3.1.2, Status and Trends). The listing status and risk

categories for the natural-origin spring Chinook salmon population would not be expected to change by the time of NMFS' next status review, but changes to the hatchery programs that have been implemented under the No-action Alternative are expected to further reduce impacts on the natural-origin spring Chinook salmon population.

The recovery goal for the Sandy River spring Chinook salmon population would not change under the No-action Alternative (Subsection 1.6, Relationship to Other Plans and Policies) (ODFW 2010a; NMFS 2013c). The natural-origin Sandy River spring Chinook salmon population would continue to be identified as a core and genetic legacy population with a recovery target of high probability of persistence (score of 3). Under the No-action Alternative, the recovery recommendations specific to the Sandy spring Chinook salmon program would be implemented, as would the general recommendations for hatchery programs.

The operation of the hatchery programs under the No-action Alternative would not be expected to have any impact on the anchor habitat or spawning areas for Sandy River spring Chinook salmon though the operation of the weirs in the Zigzag River and Salmon River impact their use by the natural-origin spring Chinook salmon population (see discussion regarding weirs below). Under the No-action Alternative, the essential physical and biological features associated with freshwater spawning, freshwater rearing, and freshwater migration that were designated as critical habitat for the LCR Chinook Salmon ESU in the action area would continue to be affected by hatchery operations, weirs, or intake structures (Subsection 3.3.1, Sandy River Spring Chinook Salmon). The weirs would be expected to have a minor impact on the habitat because they are temporary, disturb a limited area, and are operated to minimize delay in migration.

Limiting Factors and Threats

As discussed in the Updated Viability Analysis in Subsection 3.3.1.3, Limiting Factors and Threats, McElhany et al. (2007) used data through 2004 to determine that the natural-origin Sandy River spring Chinook salmon population was at moderate risk of extinction. The updated viability analysis determined that the effects of the changes in resource development, municipal water supply and hydropower development, and hatchery practices that have occurred since 2004 (e.g., removal of Marmot Dam) would not have changed the determination that the natural-origin population of spring Chinook salmon in the Sandy River was at a moderate risk of extinction, even though some of the parameters would be expected to have improved over time.

The No-action Alternative would not add or detract from the effect the changes that have occurred to the impacts from resource development and municipal water supply and hydropower development, and thus their effects would continue as described in Subsection 3.3.1.3, Limiting Factors and Threats. However, the spring Chinook salmon program is expected to have effects on the Sandy River spring Chinook salmon population, and these effects are described below.

Effects of Hatchery Programs

In Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, NMFS identified the seven factors used to evaluate the effects of the hatchery program on the natural-origin salmon

and steelhead populations. Each of these factors is reviewed below for the Sandy Hatchery spring Chinook salmon program under the No-action Alternative.

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

Potential impacts from the removal natural-origin adults for broodstock are described in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. Under the No-action Alternative, natural-origin spring Chinook salmon would not be used for broodstock and thus, there would be no effect on the natural-origin spring Chinook salmon population.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

The spring Chinook salmon hatchery program under the No-action Alternative is relatively new, and the first adult fish from the program did not return to the Sandy River to spawn until 2006. As described in Subsection 3.3.1, Sandy River Spring Chinook Salmon, the new program was recently derived from the natural-origin population, and incorporated natural-origin adults into the broodstock (at approximately 30 percent annually) until broodyear 2011 when, under the No-action Alternative, only hatchery origin adults originating from the Sandy River were used for broodstock. Because it is a new program, and because it was founded with local Sandy River-origin spring Chinook salmon, it is expected that Sandy Hatchery spring Chinook salmon are not substantially diverged from the natural-origin spring Chinook salmon population; the hatchery fish of this program are included in the LCR Chinook Salmon ESU and listed as a threatened species under the ESA (NMFS 2003a; 2004b; Jones 2011). NMFS considers the hatchery population to be integrated with the natural-origin Sandy River spring Chinook salmon population.

The risk of genetic introgression of hatchery spring Chinook salmon into the natural population was reduced between 1999 and 2007 through the removal of hatchery-origin adults at Marmot Dam. After the removal of Marmot Dam in 2007, without any structure in place to remove hatchery-origin adults, pHOS increased to 45.2 percent in 2008, and then to 77.1 percent in 2010, implying an increase in risk. More recent surveys have shown a declining trend in pHOS for spring Chinook salmon (Table 6). These declines in pHOS correspond with actions implemented by the hatchery program to reduce risk, including a reduction in smolt releases, new acclimation at the Bull Run acclimation pond, and the operation of weirs at several locations in the Sandy River Basin. All of these measures were implemented to address the high pHOS levels and in an effort to achieve the less-than-10-percent pHOS goal for the Sandy River spring Chinook salmon population that was identified in the 2010 recovery plan (ODFW 2010a). The survey results for 2013 estimated a pHOS of 9.3 percent. The preliminary pHOS estimate from the 2014 spring Chinook salmon spawning surveys was 9.8 percent (Whitman et al. 2014a).

PNI is a useful statistic for assessing the risk of hatchery-influenced selection in integrated hatchery programs. The HSRG (2009a) recommends a PNI level of 0.67, or higher, for populations that have a recovery status goal of low risk or very low risk status (see detailed discussion in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA). As described

above, PNI is a function of pHOS and pNOB (HSRG 2004; 2009a). The spring Chinook salmon program was an integrated program prior to the implementation described in the No-action Alternative. NMFS analyzed annual PNI values for return years 2008 through 2013 (Table 6). Because spring Chinook salmon returning in 2008 and 2009 included hatchery adults derived from only natural-origin adults, the PNI for these years was approximately 0.67. The weighted mean pNOB was calculated for each return year based on the proportion of each broodyear in the spawning population (from scale-based age estimates) and the pNOB for that proportion's broodyear. As pHOS increased and pNOB decreased, PNI declined to a low of 0.54 in 2011, but this was in the range (PNI greater than 0.50) where natural selective forces dominate over hatchery selective forces. This is the desired condition for all integrated programs. PNI has been increasing primarily because pHOS has been declining, and pNOB remained high for returning adults through 2012 (Table 6). Under the No-action Alternative, only hatchery adults would be used for broodstock (i.e., pNOB would be 0), and so PNI as an indicator of genetic introgression would no longer be applicable as a management goal. Under the No-action Alternative, the less-than-10-percent pHOS goal would be the measure for monitoring hatchery-influenced selection.

This less-than-10 percent pHOS goal is higher than level that was recommended by the HSRG for a segregated hatchery program to safeguard the long-term viability of the natural-origin population (HSRG 2009c; 2014). However, NMFS supports the less-than-10-percent pHOS goal that was developed by ODFW through the modeling of recovery scenarios in the ODFW Recovery Plan (ODFW 2010a). The pHOS goal for the Sandy River spring Chinook salmon population and its supporting information and analysis was incorporated into the NMFS' final Recovery Plan for ESA-listed species in the LCR (NMFS 2013c). Limiting pHOS to less than 10 percent for the Sandy River spring Chinook salmon population, along with the suite of complementary recovery actions, was shown to increase VSP parameters to the point where the Sandy River population would be viable and at very low risk of extinction (ODFW 2010a). The recovery scenarios that were evaluated for the populations in the Lower Columbia River were conservative (i.e., they were more protective for ESA-listed species) because they included additional buffers in the modeling exercise which increased the abundance and productivity standards, needed to achieve recovery. Higher standards for recovery were used to address uncertainties with regards to climate change and increasing human development. The less-than-10-percent pHOS goal is also consistent with TRT guidelines for the VSP diversity parameter presented in McElhany et al. (2007). The overall recovery goal for the Sandy River spring Chinook salmon population is to reach a low risk or very low risk of extinction (high persistence) and, under the TRT guidelines, this means that, in addition to meeting abundance and productivity targets for this designation, the average pHOS should be less than 10 percent.

Another analysis that supports the less-than-10-percent pHOS goal for the Sandy River spring Chinook salmon population is the mating-frequency material in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, and in Figure 14. Assuming random mating and complete temporal and spatial overlap, a pHOS level of 10 percent (0.1) should result in 81 percent of the matings being NxN, 18 percent being NxH, and 1 percent being HxH. This high a proportion of NxN matings should ensure a high degree of adaptation to the natural environment in the Sandy River as opposed to adaptation to the hatchery rearing environment. It is important to keep in mind that the actual proportion of genetic material arising from NxN matings would be expected to be greater than 81 percent if the assumptions of complete overlap in spawner

distribution and/or equal reproductive success of hatchery-origin and natural-origin fish are violated. Recent research shows that hatchery and natural-origin fish may segregate themselves spatially (Williamson et al. 2010b), and that hatchery spawners tend to have lower reproductive success (Williamson et al. 2010b; Berntson et al. 2011; Theriault et al. 2011). Spawning ground surveys in the Sandy River also support the observation that the distribution and survival of hatchery and natural-origin adults differ somewhat (Schroeder et al. 2013; Whitman et al. 2014b).

Under the No-action Alternative, ODFW has implemented a number of actions that have been successful in reducing spring Chinook salmon pHOS in the Sandy River. These actions include: acclimating and releasing hatchery spring Chinook salmon at the Bull Run acclimation pond so that they are less likely to stray into natural spawning areas, reducing the number of juvenile hatchery fish that are released which means there would be fewer surplus hatchery adults, after mainstem and tributary fisheries and broodstock collection, to stray into the natural spawning areas, and using seasonal weirs (as described below) to remove surplus hatchery adults before they can spawn naturally. These actions have shown success based on the pHOS of 9.3 percent observed in 2013 and the estimated 9.8 percent in 2014 (Whitman et al. 2014a).

As described in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, acclimation has been used to imprint salmon and steelhead to a unique water source with the goal of attracting the returning adults to that specific release location. Beginning in 2003, a proportion of the spring Chinook salmon production was acclimated and released from the Sandy Hatchery, and in 2006 all of the production was acclimated and released from the Sandy Hatchery (ODFW 2013b). Prior to 2003, hatchery spring Chinook salmon were not acclimated but released directly into the Sandy River downstream from the hatchery (between the hatchery and the mouth of the Bull Run River) and at other locations in the basin (ODFW 2013b). Releasing the hatchery spring Chinook salmon directly into the Sandy River prevented them from imprinting to the hatchery or to a location where the fish would home to and be selectively removed. As a result, hatchery fish tended to stray into the upper basin where habitat is more conducive to adult holding.

To address the concerns regarding straying, hatchery fish are acclimated and released at the Sandy Hatchery and are expected to return to the Sandy Hatchery as adults because they were imprinted on the scent of Cedar Creek water. However, flows within Cedar Creek are annually variable, leading to conditions in lower Cedar Creek that can discourage or even prevent hatchery spring Chinook salmon from reaching the Sandy Hatchery. As a result, returns to the Sandy Hatchery have been highly variable, as seen in 2012, when no hatchery spring Chinook salmon returned to the hatchery, compared to 2013, when 444 hatchery spring Chinook salmon returned to the hatchery (McIntosh 2013). Because of the variability in Cedar Creek flows during the time when hatchery spring Chinook salmon return, and to improve homing, an alternative site on the Bull Run River was developed and has been used for acclimating and releasing juveniles beginning in 2012.

The site for the Bull Run acclimation pond was selected because the Bull Run River is expected to have sufficient flow and preferred temperatures to attract and hold returning hatchery adults to an area where they can be harvested or removed at a weir operated in the lower Bull Run River

downstream of the acclimation site (Figure 1). In 2013, the first year of operation of the weir, 45 returning adult hatchery spring Chinook salmon were collected in the Bull Run River, and this number is expected to increase as adults return from releases in 2013, when all of the production was acclimated and released at the Bull Run acclimation pond (McIntosh 2013). Indeed, this is supported by the preliminary data from 2014 demonstrating a substantial increase in the number of hatchery spring Chinook salmon collected in 2014. Specifically, preliminary estimates show that 453 hatchery adults and 70 natural-origin adults were trapped at the Bull Run weir (Whitman et al. 2014a). It is expected that, under the No-action Alternative, hatchery spring Chinook salmon would return to the Bull Run River weir at greater numbers than prior to 2014 as more adults return from releases at the Bull Run acclimation pond than from releases at the Sandy Hatchery. This increase in return would be expected to reduce the number of hatchery spring Chinook salmon that would return to the upper Sandy River Basin, which would be monitored in terms of trapping at the weirs and through spawning ground surveys.

Another action taken to reduce the proportion of hatchery spring Chinook salmon spawning naturally, and which would be continued under the No-action Alternative, was a reduction in the total number of juveniles released relative to baseline levels (Figure 5). Production levels prior to the conversion to the locally-derived Sandy River spring Chinook salmon program were approximately 450,000 smolts annually. The release goal, under the No-action Alternative, would be 300,000 annually; this level of production began with the 2002 broodyear. All production would continue to be released from the Bull Run acclimation pond.

Under the No-action Alternative, it is expected that pHOS would continue at approximately 10 percent, as was observed in 2013 (Table 6) and estimated for 2014 (Whitman et al. 2014a). In 2011, when the operation of the weirs was tested for the first time, for part of the year[16], the pHOS declined from 73 percent to 61 percent in the primary spawning areas upstream of Marmot Dam (pHOS for the entire basin was estimated to be 66.5 percent) (Schroeder et al. 2013). In 2012, the weirs were installed earlier in the season and the resulting pHOS for the entire basin was 23.7 percent. In 2013, the weir locations were adjusted and the Bull Run weir was operated for the first time; the resulting pHOS was 9.3 percent, based on an estimated run size of 2,395 spring Chinook salmon adults (a combination of 2,172 natural-origin and 223 hatchery spring Chinook salmon) (McIntosh 2013). This trend in pHOS and the magnitude in the trend, declining from over 77 percent to less than 10 percent, appears to show that the actions taken to reduce pHOS (e.g., acclimation and release at the Sandy Hatchery and the Bull Run acclimation pond, operation of the weirs) are working. Because of these actions, the risk from hatchery-influenced selection effects on the natural-origin Sandy River spring Chinook salmon population would be expected to be low under the No-action Alternative.

The 10 percent pHOS goal for the spring Chinook salmon program under the No-action Alternative is not as protective of the natural-origin population as the 5 percent pHOS goal recommended for segregated hatchery programs as identified by the HSRG (2014). However, as described above, the 10 percent pHOS goal would be expected to result in a low risk of hatchery-influenced selection effects based on the modeling that was completed by ODFW in the

[16] The Salmon River weir was operated from September 14 to October 4, 2011, and the Zigzag River weir was operated from August 19 to September 27, 2011 (Schroeder et al. 2012).

development of its recovery plan (ODFW 2010a). Additionally, the hatchery program was derived from the natural-origin population and only ceased being an integrated program in 2011. Therefore, the probability that a natural-origin adult will spawn with another natural-origin adult is greater than 81 percent, and the acclimation of smolts at the Bull Run acclimation pond along with the operation of the weirs, would reduce the potential for hatchery spring Chinook salmon to spawn with natural-origin spring Chinook salmon.

Weir Operation

ODFW has installed and operated temporary weirs in the Zigzag River, Salmon River, and Bull Run River to collect and remove hatchery spring Chinook salmon primarily to reduce pHOS in these areas and to collect adults for hatchery broodstock. The operation of weirs at multiple locations in the Sandy Basin poses a potential threat to ESA-listed salmon and steelhead, primarily spring Chinook salmon (NMFS 2014b). There are a number of risks from the operation of weirs, including weir rejection, fallback, handling related mortality, and delay. Weir technology has improved greatly over the previous several decades and the technology is now widely and effectively applied throughout the Pacific Northwest (NMFS 2010b; 2011c).

Under the No-action Alternative, ODFW would continue to conduct spawning ground surveys to monitor effects on the naturally spawning spring Chinook salmon to determine if there are impacts from handling, and changes in spawning distribution due to weir rejection. BMPs would continue to be used to operate the weirs and to handle the fish, including:

- Properly locating the weirs. Weir function is dependent on weir design and location, such that the weir maximizes movement into the trap with adequate attraction flow; ensures adequate flow through the trap to minimize stress; trap placement to minimize spawning areas below the weir to maximize collection of hatchery adults; and minimize the areas below the trap that fish can hold forcing them to enter the trap;
- Staff the weirs to avoid overcrowding. By having adequate staffing, the adult traps can be monitored and fish passed at least daily or multiple times per day during peak migration periods;
- Providing a safe and protected holding area. A safe and protected holding area within the trap would reduce stress, and protect the fish from poaching and harassment.

The potential impacts on the species from the operation of the weirs – changes in spawning distribution and pre-spawning mortality (due to handling effects) – are expected to occur at low levels under the No-action Alternative, generally within levels that have been observed in the past before the weirs were installed and operated. For example, pre-spawning mortality is not expected to increase above pre-weir levels by more than 5 percentage points, expressed as a 3-year moving average, (i.e., an increase from 10 percent to 15 percent, not an increase from 10 percent to 10.5 percent).

Under the No-action Alternative, as many as 2,250 natural-origin spring Chinook salmon could be handled at all of the weirs (including the weir that directs fish into the adult holding pond at the Sandy Hatchery). It should be noted that handling, as referred to here, is expected to have minimal effects, lethal and sub-lethal. An analysis of the operation of the weirs in 2012 and 2013

and their effects on the natural-origin spring Chinook salmon population is provided below. This analysis updates information that was not available for the previous analysis. Under the No-action Alternative, the weirs would be operated as described below for 2013, and the impacts would be expected to be similar.

2012 Weir Operations

In 2012, the weirs were installed and operated from early July to October in the Zigzag and Salmon Rivers, and briefly at the mouth of Cedar Creek. The Cedar Creek weir was not effective in collecting adults due low Cedar Creek flow (Zweifel 2013). A total of 435 hatchery spring Chinook salmon were collected at the two upper basin weirs. The only mortality that occurred was a hatchery adult collected for broodstock, and that was due to the overloading of the portable tank during transport to the Clackamas Hatchery (Zweifel 2013). A total of 1,540 natural-origin adults were released above the weirs and no natural-origin spring Chinook salmon mortalities were reported. The weirs were checked daily until mid-September when the traps were checked twice per day as more spring Chinook salmon entered the trap. The July to September period was the driest on record in the Upper Sandy River and as a result, modifications were made to the weirs to improve attraction flows into the trap in an effort to reduce delay. The modifications were necessitated by large numbers of spring Chinook salmon observed holding below the weir (Schroeder et al. 2013). In addition, at the Salmon River trap a second sorting box was installed to expedite passage of trapped salmon (Zweifel 2013).

It is difficult to determine to what extent the Sandy River weirs in 2012 may have affected spawning distribution of spring Chinook salmon due to many factors within specific sections of the basin. Under normal conditions (i.e., in the absence of weirs) spawner distribution can vary year-to-year due to a host of environmental conditions and other factors. Add to that, the removal of Marmot Dam and corresponding changes in migration timing, changes in channel configuration and spawning gravel distribution from natural events, and habitat changes from restoration projects, all of these further complicate the analysis of spawner distribution (Schroeder et al. 2013). Schroeder et al. (2013) observed that the operation of the weir may have affected spawner distribution in limited areas immediately upstream and downstream of the weirs, but they concluded that the distribution of natural-origin adults in the primary spawning areas above the weirs, such as the Salmon and Zigzag Rivers, was more important. Schroeder et al. (2013), during spawning ground surveys in 2012, observed a small increase in the mean percentage of natural-origin spawners in the lower section of the Salmon River as compared to those observed in 2002-2007 when there were no weirs present (i.e., 20 percent versus 19 percent). In the lowest section of the Zigzag River, the mean percentage of spawning by natural-origin spring Chinook salmon was 24 percent in 2002-2007, compared to 14 percent in 2012. In addition to analysis of spawner distribution, Schroeder et al. (2013) found little evidence that the operation of the weirs delayed the timing of spawning in the Salmon or Zigzag Rivers or increased pre-spawning mortality. For 2012, Schroeder et al. (2013) identified that weir operation did not achieve the 10 percent pHOS goal because of the large number of hatchery spring Chinook salmon spawning below the weirs, and suggested that relocating the weirs farther downstream or operating the traps earlier in the year may improve collection and removal of hatchery adults.

2013 Weir Operations

The location of a weir is a key factor in determining the ability of the weir to collect adults, and it is also key to reducing potential effects on spawning distribution and delay. In 2013, the Zigzag weir was installed at the same location as in 2012, but the Salmon River weir was moved downstream 1.4 river miles to a new location approximately 0.57 river miles above the confluence with the mainstem Sandy River (Figure 1). The reason for the change in location was to improve attraction flow into the trap and to minimize holding areas below the weir. The weirs were installed in early July and operated until the end of September when a high water event led to the end of trapping operations (Alsbury 2013a). The Bull Run weir was installed for the first time in early July and was located approximately 0.15 river miles above the confluence with the mainstem Sandy River (Figure 1). These locations are where the weirs would be operated under the No-action Alternative. Modifications were made to the weir traps, including adding black fabric to the inside of the trap to prevent fish from jumping into the roof, and to provide shading to create a dark resting place, all to reduce stress and improve attraction into the trap. As in previous years, the weirs were examined daily, usually in the mornings and, beginning September 12, the traps were checked in the morning and evening to address increased movement of adults and to prevent delay. In subsequent years, under the No-action Alternative, ODFW may adjust the placement of the weirs to further improve their effectiveness and minimize impacts.

Weir efficiency and direct handling mortality were monitored in 2013. The Salmon River weir trapped 706 unmarked and 98 marked spring Chinook salmon. The Zigzag weir trapped 745 unmarked and 167 marked spring Chinook salmon. In the first year of operation, the Bull Run weir trapped 18 unmarked and 45 marked spring Chinook salmon (Lackey et al. 2013). The removal of hatchery spring Chinook salmon at the weirs was estimated to have reduced pHOS from 29 percent to 7 percent in the primary spawning areas upstream of the former Marmot Dam site (Whitman et al. 2014b). There was an incidental mortality of a natural-origin female spring Chinook salmon at the Salmon River trap on July 29, 2013. There were no visible signs of bodily damage and cause of death was unknown. Similarly, a hatchery-origin spring Chinook salmon mortality at the Bull Run trap on September 13, 2013, also did not have any signs of bodily damage (Lackey et al. 2013). Under the No-action Alternative, the impacts from the operation of the weirs on natural-origin spring Chinook salmon are expected to continue to be low, based on the effects observed in 2013, while allowing for the collection of hatchery spring Chinook salmon for broodstock and to control pHOS.

Weir Rejection

Weir operation may affect spawning distribution due to weir rejection (Subsection 4.3, Effects on Anadromous Fish Listed under the ESA). Because redd locations, observed during previous annual spawning surveys, were limited to stream sections which do not correspond to the current weir locations, ODFW compared 2013 redd distribution in three sections of the Salmon River, and three sections of the Zigzag River using the average number of redds observed in those sections in 2002 to 2007 (Figure 15). Whitman et al. (2014b) observed that the 2013 redd distribution in the Salmon and Zigzag Rivers was similar to those observed in 2002 to 2007, suggesting that the weirs did not affect the distribution of naturally spawning salmon (Figure 16 and Figure 17). The only exception was the middle sections of the Zigzag River upstream of the

weir, where the number of redds was lower in 2012 and 2013. However, ODFW suggested that this change was probably due to a major flood event that took place during the winter of 2011, which may have displaced spawning gravel and altered habitat in these sections of the river. Another explanation is storm water "diffusers" that were added to these sections after the 2011 storm (Whitman et al. 2014b). These storm water "diffusers" may have changed the scent of the water in this section, affecting the homing of the naturally spawning spring Chinook salmon. This change in proportions could also be an example of how the spawning distribution shifts naturally (fish tend to seek preferred spawning habitat) as habitat changes over time due to flood events and development. Under the No-action Alternative, the impacts from the operation of the weirs on natural-origin spring Chinook salmon are expected to continue to be low, based on the effects observed in 2013, while allowing for the collection of hatchery spring Chinook salmon for broodstock and to control pHOS.

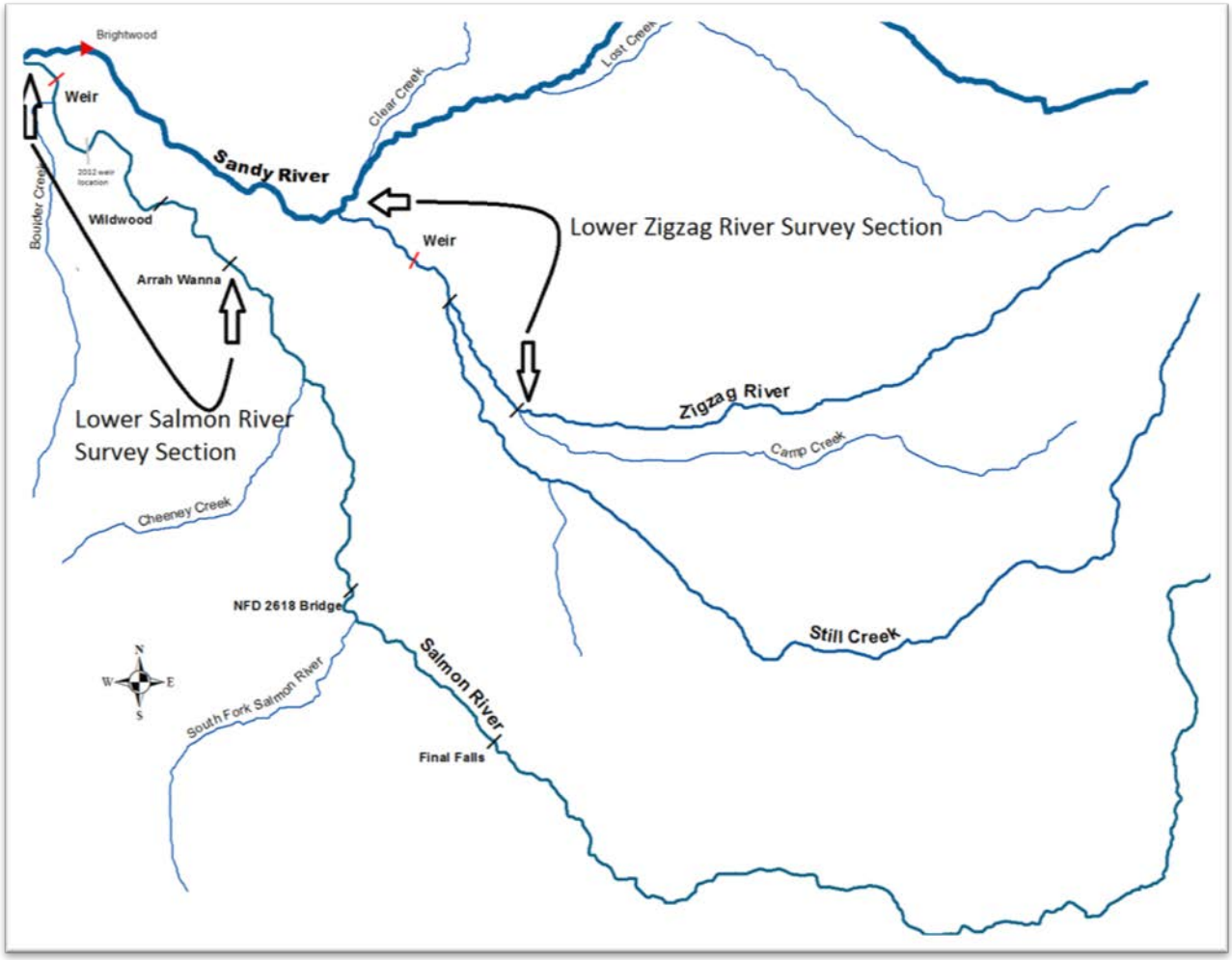

Figure 15. Upper Sandy River Basin showing location of weirs (in red) in 2013, and identifying spawning ground survey sections (in black) in the Zigzag River and Salmon River.

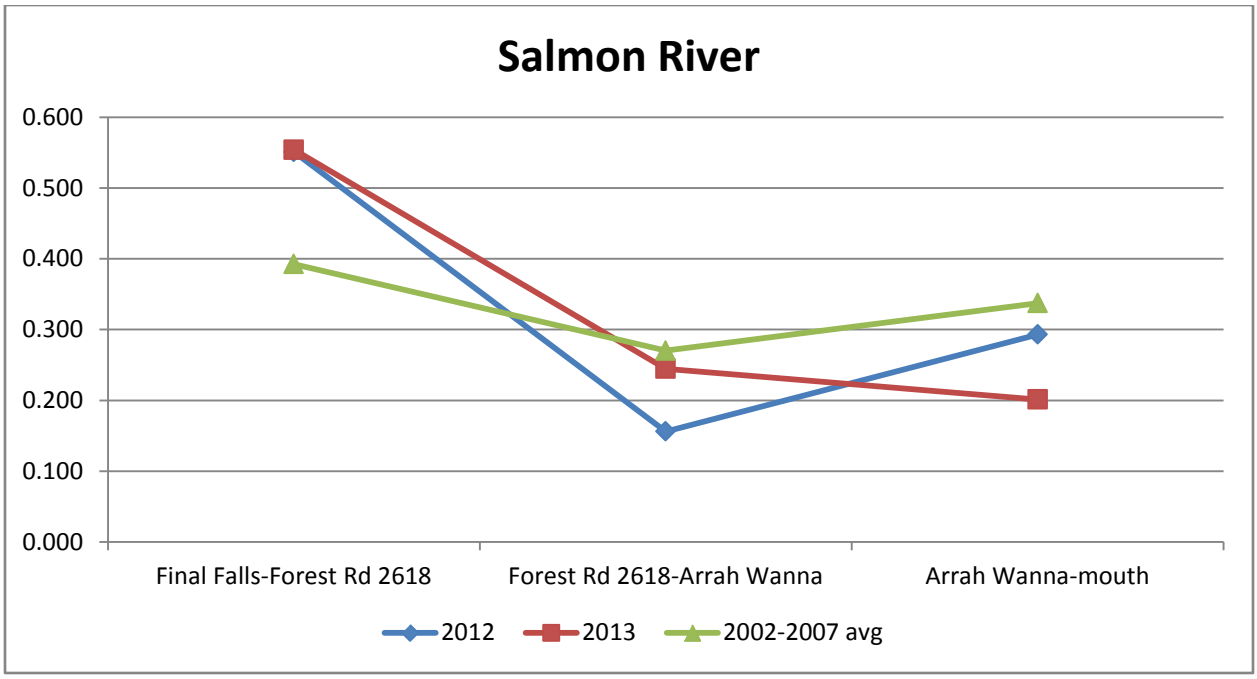

Figure 16. Proportion of the total number of redds observed in three sections of the Salmon River (Figure 15) for years 2012, 2013, and the average for return years 2002 to 2007 (Whitman et al. 2014b).

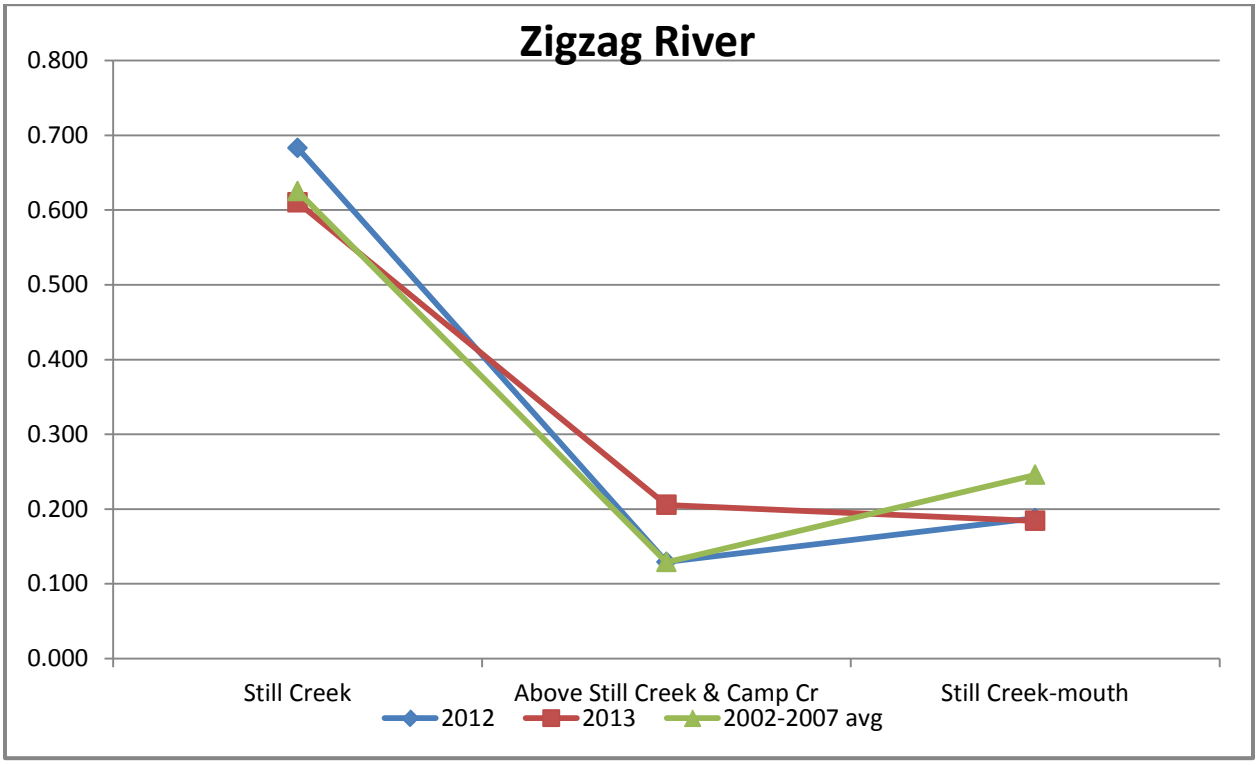

Figure 17. Proportion of the total number of redds observed in three sections of the Zigzag River (Figure 15) for years 2012, 2013, and the average for return years 2002 to 2007 (Whitman et al. 2014b).

Migration Delay

Delay in the upstream migration of spring Chinook salmon due to the installation and operation of the weirs in the Salmon and Zigzag Rivers may affect the date of first spawning, and the peak spawning date. In 2013, the date of first spawning was within the normal range for the Salmon River below Arrah Wanna and for the Zigzag River above Still Creek (Figure 18), but was earlier than the range seen in the past for the upper Salmon River above Arrah Wanna (Figure 18). These are sections or river reaches where data from previous surveys are available (Whitman et al. 2014b).

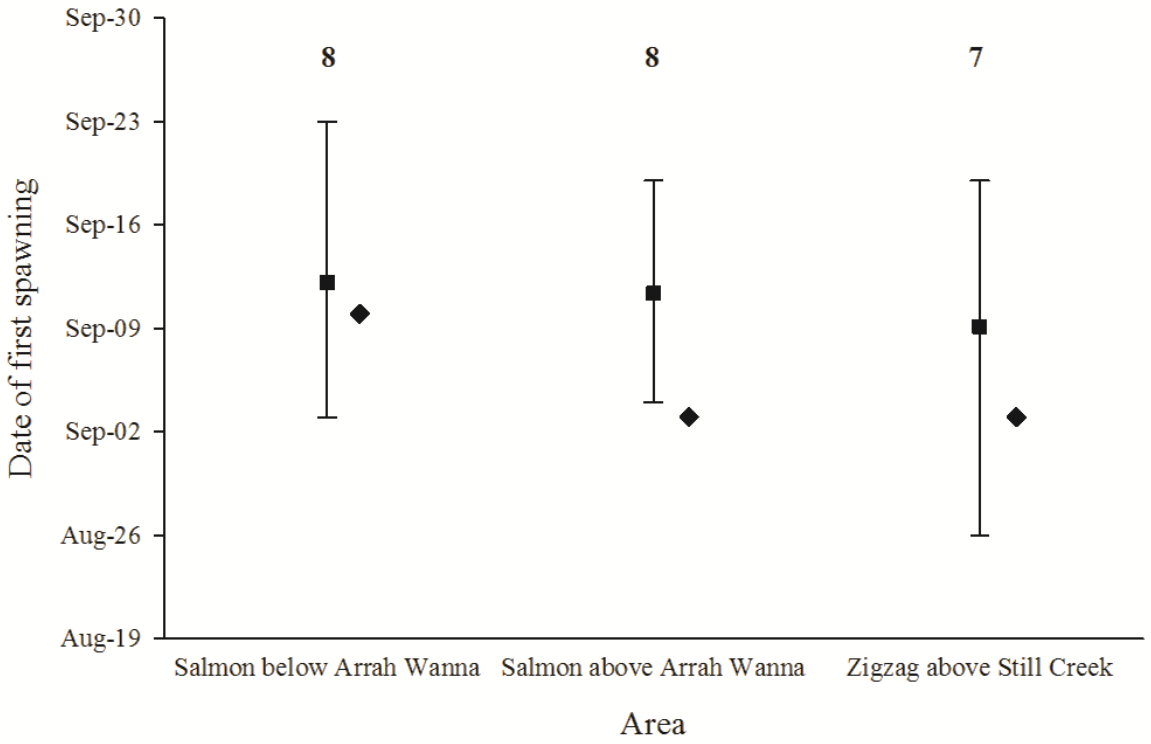

Figure 18. Date of first spawning for spring Chinook salmon in the Salmon and Zigzag river basins for 2002-2009 (mean, ■), and in 2013 (♦). The capped vertical lines are the range and the numbers above the lines are the number of years in the data set. Data for 2010 were not included because surveys started late. 2003 data for the Zigzag River Basin is not included because surveys were more than two weeks apart between early and late September (Whitman et al. 2014b).

In 2013, the peak spawning date was earlier than the mean date for the Zigzag River and the upper section of the Salmon River, but these were within the range observed in the past (Figure 19). The peak spawning date in the middle and lower sections of the Salmon River was earlier than what has been seen in the past and ODFW suggests that this is probably due to the major storm event that occurred in late September (Alsbury 2013a; Whitman et al. 2014b). These

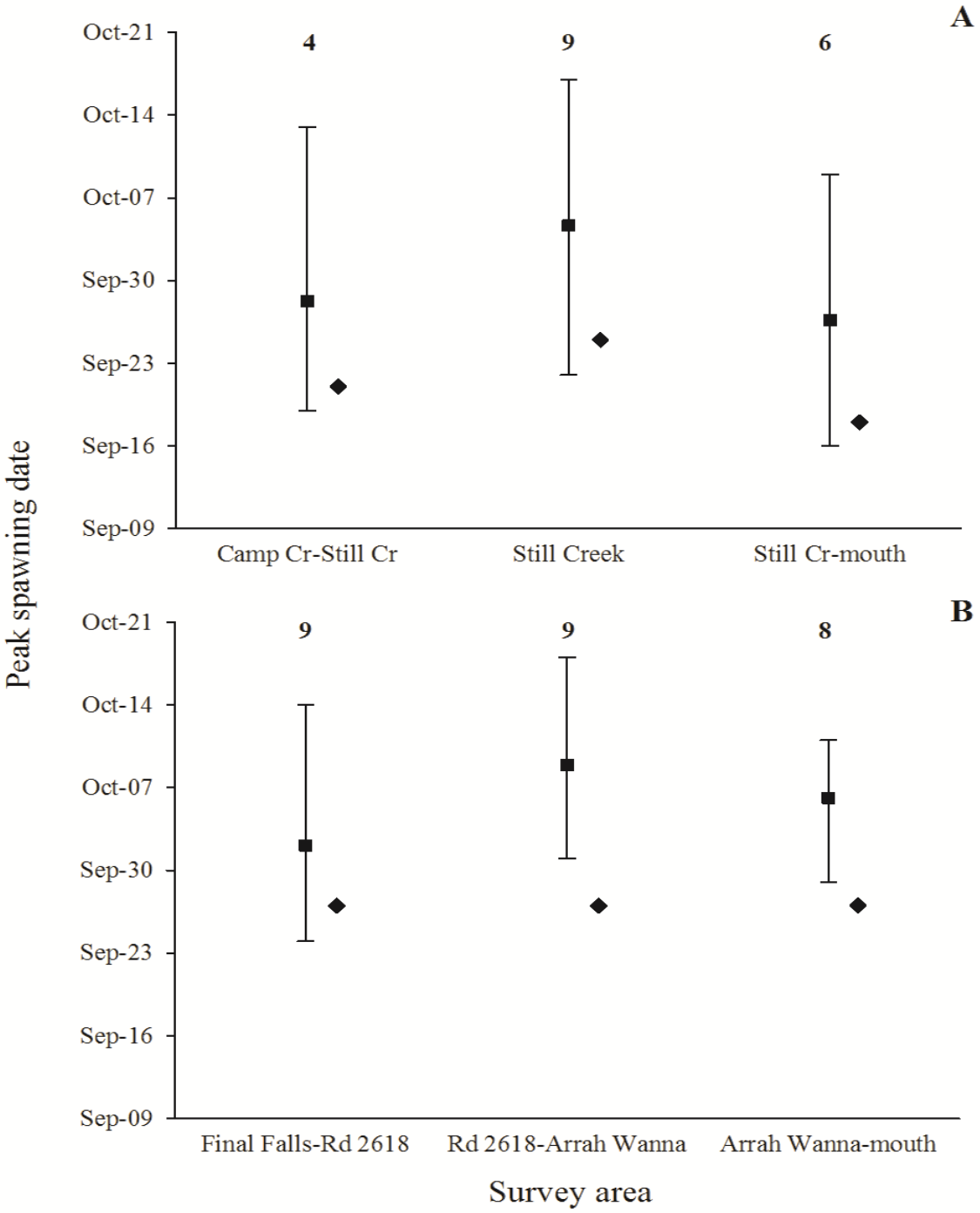

Figure 19. Peak spawning dates of spring Chinook salmon in the Zigzag (A) and Salmon (B) river basins in 2002-2010 (mean, ■) and in 2013(♦). The capped vertical lines are the range and the numbers above the lines are the years in the data set. Years were excluded when only a single survey was conducted (Zigzag River) or when no late surveys were conducted (lower Salmon River)(Whitman et al. 2014b).

findings do not indicate delay, but do show the level of variability between years and the effect of environmental factors on spring Chinook salmon spawning.

In 2013, on the Salmon River and Zigzag Rivers, snorkel surveys were conducted once a week to identify hatchery and natural-origin adult spring Chinook salmon and to determine if fish were holding directly below the weirs (Lackey et al. 2013). Surveys were conducted in the section of river from the Zigzag weir 1.25 miles downstream to the Lolo Pass Road Bridge (Figure 15). Two sections were surveyed on the Salmon River: a 1.4 mile section from the 2012 weir site to the current weir location, and the 0.57 mile section from the weir to the mouth of the Salmon River. Spring Chinook salmon were observed primarily holding in one deep pool underneath the Brightwood Bridge that crosses the Salmon River approximately 0.22 RM downstream of the weir. If a substantial number of fish were observed holding directly below the weir, a plan was in place to remove panels from the weir allowing for unimpeded passage. This action was not necessary in 2013 because adult spring Chinook salmon were not observed holding directly below the trap, and the number of fish that entered and move through the trap continued to increase (Figure 1 and Figure 2 in Lackey et al. (2013)).

Figure 1 in Lackey et al. (2013) shows an increase in the snorkel count below the Salmon River weir but not a corresponding increase in passage over the weir the following week. This could be an indication of delay due to the weir or it could be due to environmental and physiological factors. As observed in 2012 and again in 2013, spring Chinook salmon begin to move in larger numbers during the first two weeks of September (Lackey et al. 2013). The observed increase in the first weeks in September triggers ODFW to begin checking the trap twice a day, once in the morning and again in the evening. During the September 10, 2013 snorkel survey, spring Chinook salmon were observed to have migrated from the mainstem Sandy River into the Salmon River and into the deep hole under the Brightwood Bridge. This movement may have been due to a corresponding decline in the flow in the mainstem Sandy River, which may have resulted in higher glacial silt loads (Whitman et al. 2014b).

There are no direct flow measurements for the Salmon River (i.e., no river gauges), but the Blaze Alder Creek gage (in an unregulated, non-glacial tributary to the upper Bull Run River) serves as a surrogate for flows in the Salmon River. Blaze Alder Creek drains most of the southern portion of the Bull Run watershed coming into the Bull Run River between Bull Run Lake and Bull Run Dam #1. Comparing the flow in Blaze Alder Creek with trap counts at the Salmon River weir show the same pattern (Figure 20), with a decrease in passage corresponding to a decrease in flow, and a subsequent increase in passage as flow increased. It is difficult to discern based on the limited data whether the decline in passage was an effect of the weir or due to environmental factors. The delay of natural-origin spring Chinook salmon migration is the primary concern, and ODFW proposes under the No-action Alternative to conduct additional snorkel surveys beginning the first week of September, to estimate of the proportion of natural-origin and hatchery spring Chinook salmon below the weirs. The additional surveys are expected to provide an assessment of whether or not the weir is delaying natural-origin fish migration and additional information on the proportion of hatchery fish below the weir. Tracking cumulative passage at the trap only shows a slight slowdown that corresponds with a decrease in stream flow, and then an increasing trend the following week as tributary flows increased (Figure 20). Under the No-action Alternative, the impacts from the operation of the weirs on natural-origin spring Chinook

salmon are expected to continue to be low, based on the effects observed in 2013, while allowing the collection of hatchery spring Chinook salmon for broodstock and to control pHOS.

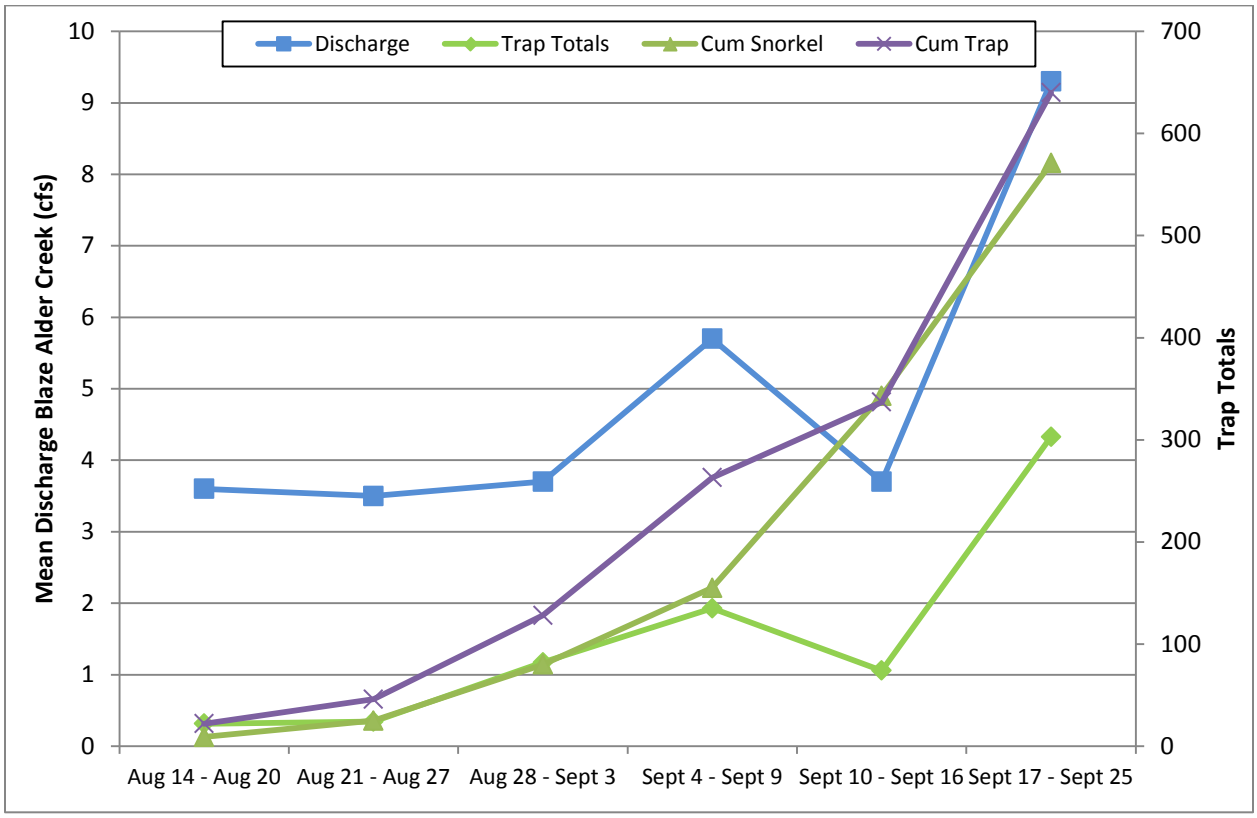

Figure 20. Salmon River trap weekly totals, cumulative snorkel survey counts, and cumulative trap counts relative to Blaze Alder Creek discharge (Blaze Alder Creek is a small, un-regulated tributary to the Bull Run River and is used as a surrogate because flow data for the Salmon River is not available) (Lackey et al. 2013).

Delayed Trapping and Handling Mortality

The effects on natural-origin spring Chinook salmon from delay and handling of adults at the weirs can be estimated through comparisons of pre-spawning mortality levels in the Zigzag and Salmon Rivers before and after the weirs were installed. For the period from 2003 to 2007, spring Chinook salmon were trapped and handled at Marmot Dam and this likely resulted in some level of increased pre-spawning mortality. Trapping and handling fish at Marmot Dam was expected to result in increased stress and pre-spawning mortality because the facilities there were not designed to trap and handle fish (Subsection 3.3.1, Sandy River Spring Chinook Salmon).

In 2008 and 2009, after the removal of Marmot Dam and before the operation of weirs in the upper basin the percentage of naturally spawning spring Chinook salmon that died prior to spawning (i.e., pre-spawning mortality) averaged 8.2 percent in the Salmon River, and 2.9 percent in the Zigzag River (Whitman et al. 2014b). In 2012 and 2013, pre-spawning mortality was estimated from the observation of unspawned or partially spawned adult spring Chinook salmon carcasses collected during spawning ground surveys. Schroeder et al. (2013) observed

that the pre-spawning mortality in the upper Sandy River Basin was slightly lower in 2012 compared to the 2003 to 2009 period. They noted that during this period the pre-spawning mortality was variable in the upper Sandy River Basin (range = 0 to 17 percent), slightly lower than the variability observed in the upper McKenzie (range = 0 to 20 percent) or the upper Clackamas (range = 0 to 29 percent) basins, and that the pre-spawning mortality in the Sandy River Basin appeared to track the other two basins, suggesting that regional factors common to several populations of spring Chinook salmon may be a primary influence on mortality (Schroeder et al. 2013). Schroeder et al. (2013) observed no difference between pre-spawning mortality above and below the weirs for natural-origin adults in 2012, but did observe that pre-spawning mortality was higher for hatchery adults below the weir than above the weir. In the Salmon River, the pre-spawning mortality of hatchery fish was about two times higher than for natural-origin spring Chinook salmon above the weir, and was almost five times higher than natural-origin spring Chinook salmon downstream of the weir (Schroeder et al. 2013). Of note is evidence that hatchery spring Chinook salmon in the Sandy River are subject to substantially higher pre-spawning mortality relative to natural-origin fish, which indicates that pHOS and the effective pHOS (i.e., those hatchery fish that not only make it to the spawning grounds but that also survive long enough to spawn) are likely lower than previously expected.

Preliminary results from (Whitman et al. 2014b) compared pre-spawning mortality in 2013 to that in 2003 to 2007 (when adults were handled at Marmot Dam) and 2008 to 2009 when no weirs were operated in the basin and Marmot Dam was gone (2002 and 2010 were not included because the surveys did not start until mid-September). Pre-spawning mortality in the upper Sandy River Basin was lower in 2013 than in previous periods (Whitman et al. 2014b). In individual basins, the Salmon River was lower than the two comparison periods and in 2012, but the Zigzag River was higher than the comparison periods but lower than 2012 (Whitman et al. 2014b). The observed difference in the Zigzag River may be due to the small sample size observed in earlier years when spawning surveys were conducted during periods of high glacial melt causing poor visibility affecting the ability to recover carcasses. In 2013, pre-spawning mortality was somewhat higher upstream of the weirs than downstream of the weirs for both hatchery and natural-origin spring Chinook salmon in the Salmon and Zigzag watersheds; however, the sample sizes were small downstream of the weirs (Whitman et al. 2014b). As observed in 2012, the pre-spawning mortality of hatchery spring Chinook salmon above and below the weirs was more than twice that observed for natural-origin spring Chinook salmon (Whitman et al. 2014b).

The estimated pre-spawning mortality was 5 percent in the Bull Run River (including the Little Sandy River) where one spring Chinook salmon pre-spawning mortality was recovered at the weir in mid-September, along with 19 carcasses from spawned-out females collected in the last two weeks of October (Whitman et al. 2014b). Estimates of pre-spawning mortality in the Bull Run River Basin prior to 2013 are limited and are not representative due to small sample sizes.

Under the No-action Alternative, the impacts of the operation of the weirs on natural-origin spring Chinook salmon are expected to continue to be low, based on the effects observed in 2013 when all three weirs were operated to collect hatchery spring Chinook salmon for broodstock and to achieve less than 10 percent pHOS. Spawning ground surveys would be continued under the No-action Alternative to monitor the effects of weir rejection, migration delay, and delayed

handling mortality due to the operation of the weirs. Under the No-action Alternative, the release of hatchery spring Chinook salmon smolts from the Bull Run acclimation pond is expected to cause the majority, if not all, of the hatchery spring Chinook salmon adults to return to the Bull Run weir. If monitoring shows that the proportion of hatchery spring Chinook salmon removed at the Zigzag River and Salmon River weirs are at such low levels that the estimated pHOS would be below the 10 percent goal if they were not trapped and removed, then the two upper basin weirs would not be operated, thereby reducing impacts associated with the weirs.

Accounting for Environmental Conditions when Evaluating Hatchery Weir Effects

Risk assessments for fish and wildlife species are complicated by synergistic affects resulting from multiple environmental and human affected factors. This is particularly true for Pacific salmon species that have a wide-ranging and complicated life cycle.

Stream-flows affect salmon and steelhead behavior and every aspect of their survival in freshwater and there has been unprecedented variability in Sandy River stream-flows during recent years. The record low rainfall recorded in the summer of 2012 (Zweifel 2013), which was followed by a record high water event at the end of September in 2013 (Alsbury 2013a; Lackey et al. 2013) illustrates this variability. Furthermore, even excluding the effects of these types of weather events, there is natural variability due to the factors outside the Sandy River Basin that affect the survival and productivity of the natural-origin populations in the Sandy River. These outside factors affect smolt-to-adult survival – for example, the estimated smolt-to-adult survival rates for the winter steelhead program ranged from a low of 0.45 percent to a high of 1.88 percent for broodyears 2000 to 2007 (ODFW 2013e). These variations in survival are manifested in changes in the abundance of natural-origin adults as seen in Table 5. Variability is also seen in things like spawning distribution (Schroeder et al. 2013; Whitman et al. 2014b), time of first spawning, (e.g., for the Zigzag River above Still Creek the ranges was from August 25 to September 20 (Whitman et al. 2014b) and peak spawning (e.g., in the Salmon River in the upper most section peak spawning ranged from September 24 to October 15 (Whitman et al. 2014b).

In evaluating the effects under the No-action Alternative of the weir operation and other factors (i.e., pHOS) on natural-origin spring Chinook salmon, it is necessary to identify changes to the natural populations that are due to the operation of the weirs and not due to changes in the natural environment. Spring Chinook salmon live under highly variable conditions (from freshwater to the ocean and back again) and a single measurement would not provide the most accurate indication of both the status of the populations or the factors that affect them. This is the primary reason for using a 3-year moving average. Determining the 3-year moving average would begin with data from the first year after the hatchery programs are approved and operated as described under the No-action Alternative.

Beginning with the first year of data after the implementation of the program would ensure that the factors being evaluated reflect how the approved hatchery programs are being operated, and not evaluating how the hatchery programs were operated in the past. These data would be monitored closely to determine if the goal is exceeded sufficiently in one year that the 3-year moving average could not be achieved. For example, if the pHOS goal was 10 percent, and in the first year of monitoring the pHOS was estimated to be 8 percent, then the following year it was 23 percent, the result would be that the pHOS goal of 10 percent (based on a 3-year moving

average) could not be achieved the following year. This result would trigger an evaluation by NMFS and ODFW to identify factors causing such failure to meet the goal. Measures that could be taken to increase the likelihood of achieving the goal in the future could then be identified.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery spring Chinook salmon are expected to have a negligible effect on natural-origin juveniles under the No-action Alternative.

Competition

Competition can occur when hatchery fish and the progeny of naturally spawning hatchery fish compete for rearing areas and food with fish from the local natural population(s). In the Sandy River, there is little or no spatial or temporal overlap in the distribution of hatchery and natural-origin fish except in recent years for spring Chinook salmon. Competition between hatchery and natural-origin spring Chinook salmon is expected to be minor or negligible because hatchery spring Chinook salmon tend to segregate themselves from natural-origin fish (Williamson et al. 2010b), as illustrated in the Sandy River where the majority of the marked hatchery fish were recovered in the lower river sections of Sandy River Basin outside the preferred natural spawning and rearing habitats in the Salmon and Zigzag Rivers (Schroeder et al. 2013; Whitman et al. 2014b). This spatial segregation is expected as best management practices for rearing, acclimating, and releasing hatchery spring Chinook salmon take effect. The combination of low and declining pHOS, differences in spatial distribution between, and the lower reproductive success for naturally spawning hatchery fish under the No-action Alternative would be expected to result in a negligible effect from competition between hatchery fish and fish from ESA-listed natural-origin populations (Williamson et al. 2010b; Berntson et al. 2011; Theriault et al. 2011).

The release of all hatchery spring Chinook salmon smolts at the Bull Run acclimation pond is expected to mitigate the potential for competition between hatchery and natural-origin fish under the No-action Alternative. The acclimation pond is downstream of the primary natural production areas for spring Chinook salmon in the Sandy River creating greater spatial separation between hatchery adults, the progeny of naturally spawning hatchery fish, and natural-origin salmon in the Sandy River. Another factor contributing to the reduced potential for competition would be the dramatic declines in hatchery production/smolt releases (Figure 5).

As described in the discussion of competition under Factor 3 (Subsection 4.3, Effects on Anadromous Fish Listed under the ESA), natural-origin Chinook salmon tend to have a more protracted emigration, while hatchery fish that are relatively uniform in size and behavior leave the river quickly, reducing the potential for interactions with natural-origin juveniles. This behavior was confirmed during outmigration monitoring studies in the Bull Run River. These studies use a rotary screw trap to monitor and evaluate the salmon and steelhead juvenile outmigration, and experience shows that the trap must be removed, but only temporarily, after hatchery spring Chinook salmon are allowed to leave the acclimation pond just upstream from

the trap site. Hatchery fish leave the system *en masse* and would overwhelm the trap if it continued to operate during the hours immediately following hatchery fish release. Temporary removal of the trap also means that natural-origin fish that might encounter the trap during this short period are not exposed to excessive stress and mortality caused by large numbers of hatchery fish in the trap. In 2012, after two releases of hatchery spring Chinook salmon smolts totaling 97,756, and following the procedure described above, only 72 hatchery spring Chinook salmon smolts, or less than 0.07 percent of the total release, were trapped two days or more after release. Similarly, in 2013, after two releases totaling 129,923 smolts, only 237, or 0.15 percent of the total release, were trapped. Trap efficiency is not 100 percent but these numbers are clearly consistent with hatchery spring Chinook salmon smolts emigrating quickly after release.

Under the No-action Alternative, ODFW would sample juvenile rearing areas in the lower Sandy River 21 days after the hatchery releases to determine if juvenile hatchery smolts are promptly leaving the basin as expected. Results from 2013 sampling showed that hatchery smolts moved quickly that year and did not stay long in the Sandy River to interact with and potentially compete with natural-origin fish (Alsbury 2013b). No hatchery spring Chinook salmon were present during sampling in these lower river areas (Alsbury 2013b). Based on the information provided above, NMFS expects under the No-action Alternative that the majority of the hatchery salmon and smolts would leave the Sandy River quickly, due to their uniform size and condition, thus posing a low risk to ESA-listed natural-origin spring Chinook salmon from competition.

Displacement

In other stream systems, *en masse* hatchery salmon smolt releases have been observed to cause the displacement of naturally produced juvenile salmonids, leading to the abandonment of advantageous feeding stations or premature out-migration (Pearsons et al. 1994). Displacement and premature out-migration would be expected to reduce population spatial structure and abundance. Under the No-action Alternative, this possibility was considered but these effects are not expected to occur, for two reasons. First, hatchery fish are not released into areas preferred by natural-origin fish for rearing. Second, natural-origin Chinook salmon are already actively migrating to the ocean by the time they reach areas in the mainstem Sandy River where the hatchery fish would be encountered. Therefore, natural-origin smolts would be expected to continue their migration unaffected by the presence of hatchery smolts.

Predation

Predation is dependent upon many factors (Pearsons and Busack 2012), but two major prerequisites are that the predatory fish and their prey must overlap temporally and spatially, and the prey should be less than 1/3 the length of the predatory fish. Because there is little temporal or spatial overlap between hatchery smolts and natural-origin fish, there is no known threat from predation or competition. Under the No-Action Alternative, the release of hatchery coho salmon and steelhead smolts may contribute to predation on tule, and late-fall Chinook salmon juveniles in the lower Sandy River however this is expected to be minor because outmigrating coho salmon and steelhead smolts tend to move out of the Sandy River quickly after release and on their downstream migration occupy habitat that is not used by rearing juvenile fall Chinook salmon which prefer habitat on the river margins out of the main current.

Available data shows that hatchery smolts leave the Sandy River promptly and that only a small fraction remain in the system 21 days after release; ODFW would monitor the river for the presence of hatchery smolts in this time frame under the No-action Alternative. The small number of fish that remain the system would have a negligible effect on ESA-listed natural populations. These fish would be expected to reside in the vicinity of where they were released, miles downstream from the most important salmon and steelhead production areas. Under the No-action Alternative, NMFS would require that ODFW monitor and report annually on the presence and absence of juvenile hatchery fish in the Sandy River downstream of the Sandy Hatchery. Monitoring results would provide information on hatchery fish outmigration and the potential for competition and predation between hatchery and natural-origin fish.

Under the No-action Alternative, the risk of adverse ecological interactions would be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile natural-origin fish in freshwater (Steward and Bjornn 1990).
- Operating the hatchery such that hatchery fish are reared to sufficient size that smoltification occurs within nearly the entire population (Bugert et al. 1991).
- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing natural-origin juveniles.
- Monitoring interactions in the Sandy River Basin between juvenile hatchery and natural-origin fish.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean. At full production, hatchery releases from the four Sandy River programs would constitute less than 1 percent of the total hatchery production and less than 0.05 percent of all juvenile salmonids in the Columbia River Basin (Table 2). The SCA for the FCRPS opinion (NMFS 2008h) and the September 2009 FCRPS Adaptive Management Implementation Plan (AMIP) (NMFS 2009) both concluded that available knowledge and research abilities are insufficient to discern any important role or contribution of hatchery fish in density-dependent interactions affecting salmon and steelhead growth and survival in the mainstem Columbia River, the Columbia River estuary, and in the Pacific Ocean.

From the scientific literature, the general conclusion is that the influence of density dependent interactions on growth and survival is likely minor compared with the effects of large scale and regional environmental conditions and while there is evidence that hatchery production, on a scale many times larger than the proposed action, can impact salmon survival in the migration corridor, estuary, and ocean, the degree of impact or level of influence is not yet understood or predictable. Regardless, hatchery production on the scale considered in this opinion is unlikely to substantially affect salmon survival or recovery in these life stages. NMFS would monitor emerging science and information and would reinitiate Section 7 consultation in the event that

new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

Under the No-action Alternative, ME&R activities would continue to monitor the Performance Indicators identified in Section 1.10 of the HGMPs, ensure compliance with the 2012 Biological Opinion (NMFS 2012b), and inform future decisions regarding how the hatchery programs can be adjusted to meet their goals while further reducing effects on ESA-listed salmon and steelhead. Minor lethal and sub-lethal effects on ESA-listed natural-origin fish are expected to occur from the handling of juveniles during the operation of the screw trap in Cedar Creek, and during the juvenile sampling in the lower mainstem Sandy River. ODFW would monitor and report annually on pHOS and the distribution of naturally spawning hatchery fish in the Sandy River and its tributaries. Adult salmon and steelhead would also be monitored at the weirs, including the weir on Cedar Creek, and the effect on natural-origin adults is addressed above.

Under the No-action Alternative, spring Chinook salmon would not be affected by the operation of the rotary screw trap in Cedar Creek because spring Chinook salmon are not passed above the Sandy Hatchery. Under the No-action Alternative, up to an estimated 1,000 natural-origin Chinook salmon juveniles could be handled during the monitoring for the presence and absence of juvenile hatchery fish in the Sandy River downstream of the Sandy Hatchery. ODFW estimates that potentially up to 30 juveniles could die from handling. The first evaluation was conducted in 2013 and included sampling in the lower Sandy River below the mouth of the Bull Run River. The total number of hatchery fish observed during sampling was two steelhead smolts, no other hatchery origin juveniles were observed out of the 320 juvenile Chinook salmon sampled (Alsbury 2013b).

Under the No-action Alternative, masking caused by hatchery fish would not be a threat to ESA-listed salmon in the Sandy River. Hatchery fish from these programs would not confuse or conceal the status of a natural population or the effects of the hatchery program on any natural population. It is expected that there would be little spatial or temporal overlap in distribution between hatchery fish and fish from natural populations in the Sandy River. In addition, hatchery fish from the four programs would be 100 percent adipose fin-clipped for easy identification. Hatchery spring Chinook salmon are also blank-wire tagged and otolith marked to increase the effectiveness of identification. Marking and tagging of fish may have adverse effects on the survival or viability of the marked fish; however, because hatchery fish are not meant to spawn naturally and contribute to the natural population, the reduction in survival due to marking would not affect the natural populations. Furthermore, no natural-origin fish are proposed for marking.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the spring Chinook salmon hatchery program would continue to have a negligible effect on ESA-listed species under the No-action Alternative. Under the No-action Alternative, no new construction

at the Sandy Hatchery would occur and thus, no effects would be expected. Water intake structures and water withdrawal present another set of potential effects on listed salmonids, and these were evaluated in Subsection 4.2, Effects on Water Quality and Water Quantity.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsection 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

Summary of Risk Effects

Based on the discussion above, under the No-action Alternative, the release of hatchery salmon and steelhead would be expected to have minor impacts on listed Chinook salmon in the Sandy River Basin. Impacts on spring Chinook salmon would occur from the collection of broodstock and the removal hatchery adults at the tributary weirs, which may handle a substantial proportion of the natural-origin adults returning to the basin. Impacts from handling at weirs are expected to be low, based on past observed mortalities and analysis of spawning ground surveys that show little or no effect from the operation of the weirs due to weir rejection, migration delay, and pre-spawning mortality. Under the No-action Alternative, these spawning ground surveys are expected to continue to monitor the effects of weir operation on natural-origin spring Chinook salmon.

Genetic introgression from hatchery-influenced selection effects due to naturally spawning hatchery spring Chinook salmon is expected to generally remain at or below the low levels observed in 2013 and 2014, due to the operation of the weirs to remove hatchery spring Chinook salmon adults, the continued release of hatchery spring Chinook salmon from the Bull Run acclimation pond, and the reduced production levels compared to the historical releases. However, as the spring Chinook salmon hatchery program continues to use only returning hatchery adults for broodstock, the risk from hatchery-influenced selection effects may increase because the pHOS goal of 10 percent exceeds the 5 percent goal as recommended for segregated programs by the HSRG (2014). As discussed above (under Factor 2), risks from hatchery-influenced selection would be expected to remain low primarily because the hatchery spring Chinook salmon were recently derived from the natural-origin population and the program incorporated natural-origin adults into the broodstock until 2011. Consequently, the hatchery population would not have had the opportunity to diverge from the natural-origin Sandy River spring Chinook salmon population.

The release of hatchery coho salmon and steelhead may contribute to predation on emergent and rearing fall Chinook salmon in the lower Sandy River; however, it is expected that this impact would be low because of the actions taken to produce smolts that emigrate rapidly from the basin, minimizing the encounter rates, and because the smolts and juvenile salmon occupy non-

overlapping habitats in the lower mainstem Sandy River. Under the No-action Alternative, the reduction of impacts may contribute to lowering the risk of extinction for the Sandy River spring Chinook salmon population, but would not be expected to have an effect on the very high risk of extinction for the LCR Chinook Salmon ESU as a whole because of factors affecting the ESU outside the action area (Subsection 3.3.1, Sandy River Spring Chinook Salmon).

4.3.1.2. Sandy River Coho Salmon

Subsection 3.3.2, Sandy River Coho Salmon, describes populations that are part of the LCR Coho salmon ESU including the Sandy River coho salmon population. All of the other coho salmon populations and their associated habitat reside outside the action area and would not be affected under the No-action Alternative.

Life History

Under the No-action Alternative, impacts on the life history of the coho salmon population in the Sandy River would not be expected to occur. The hatchery coho salmon program could have impacts on the life history characteristics of the natural-origin coho salmon population, but these impacts are expected to be minimal, over the near term, because NMFS (2003a) determined that the Sandy River hatchery coho salmon program was no more than moderately diverged from the natural population in the watershed and that the stock was derived from the local, natural-origin population. It is not considered to be minimally divergent because the hatchery program did not incorporate substantial numbers of natural-origin fish into the broodstock. Based on this determination, NMFS considers the hatchery program to be integrated with the natural population. However, over the long term, the coho salmon program under the No-action Alternative may impact the life history characteristics of the natural-origin coho salmon population because natural-origin coho salmon are not used for broodstock and as a result of the hatchery coho salmon continuing to interbreed with the natural population.

Status and Trends

The status and biological risk categories identified in Ford (2011) concluded that the LCR Coho Salmon ESU is at very high risk of extinction; however, the Sandy River coho salmon population was considered to be at high to moderate risk of extinction. ODFW (2010a) determined that the Sandy River coho salmon population abundance and productivity parameter had decreased relative to that observed by McElhany et al. (2007), and this contributed to the lowering of the overall status to high risk (Figure 8).

The listing status and risk categories for the natural-origin coho salmon population would not be expected to change by the next status review, but changes to the hatchery programs that have been implemented under the No-action Alternative are expected to further reduce impacts on the natural-origin coho salmon population. These hatchery changes, along with factors affecting VSP parameters, may improve the overall status of the population over the long term. The hatchery program would continue to pose risks under the No-action Alternative due to naturally spawning hatchery fish, but these risks are expected to be minor. To the extent that adverse impacts on Sandy River coho salmon populations under the No-action Alternative are reduced,

NMFS expects that the productivity of the natural-origin population would increase, leading to more adults returning to the Sandy River Basin compared to recent levels (Table 5).

The operation of the hatchery programs under the No-action Alternative would not be expected to have any impact on the anchor habitat or spawning areas for Sandy River coho salmon though the operation of the tributary weirs, and the adult weir at the Sandy Hatchery may impact their use by the natural-origin coho salmon population (see discussion regarding weirs below). Critical habitat has not been designated for the LCR Coho Salmon ESU.

The recovery goal for the Sandy River coho salmon population would not change under the No-action Alternative (Subsection 1.6, Relationship to Other Plans and Policies) (ODFW 2010a; NMFS 2013c). The natural-origin Sandy River coho salmon population would continue to be identified as key to recovery of the Cascade coho salmon strata and the LCR Coho Salmon ESU with a target of high probability of persistence (score of 3).

Limiting Factors and Threats

Subsection 3.3.2.3, Limiting Factors and Threats, describes how McElhany et al. (2007) and ODFW (2010a) used data through 2004 to determine that the natural-origin Sandy River coho salmon population was at a high risk of extinction. The updated viability analysis describes the effects of changes in resource development, municipal water supply hydropower development, and hatchery practices that have occurred since 2004 (e.g., removal of Marmot Dam and Little Sandy River diversion dam). These effects would not have changed the determination that the natural-origin population of coho salmon in the Sandy River was at high risk of extinction, though the overall status would be expected to improve as productivity increases due to additional habitat in the Little Sandy River and upper Cedar Creek along with potential benefits from the reduction in hatchery coho salmon releases.

The No-action Alternative would not add or detract from the effect the changes that have occurred to the impacts from resource development and municipal water supply and hydropower development, and thus their effects would continue as described in Subsection 3.3.2, Sandy River Coho Salmon. However, the coho salmon program is expected to have effects on the Sandy River coho salmon population, and these effects are described below.

Effects of Hatchery Programs

In Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, NMFS identified the seven factors used to evaluate the effects of the hatchery program on the natural-origin salmon and steelhead populations. Each of these factors is reviewed below for the Sandy Hatchery coho salmon program under the No-action Alternative.

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

Under the No-action Alternative, natural-origin coho salmon would not be used for broodstock and, thus, there would be no effect on the natural-origin coho salmon population.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential genetic effects from hatchery-influenced selection on the natural-origin coho salmon population can occur from hatchery fish spawning naturally. The No-action Alternative includes the operation of an segregated coho salmon program using the current stock of hatchery coho salmon released at the Sandy Hatchery. The pHOS goal for the coho salmon program under the No-action Alternative would be 10 percent. Best available scientific information shows that of the Sandy Hatchery coho salmon are little enough diverged from the natural population (NMFS 2003a; 2004b; Jones 2011) to be included in the ESA-listed ESU. Sandy River Hatchery coho salmon contain genetic resources that represent the evolutionary legacy of the natural population in the Sandy River (NMFS 2003b). For this reason, NMFS considers Sandy River hatchery coho salmon and the Sandy River coho salmon natural population to be integrated.

Because the hatchery program was derived from the local natural-origin coho salmon population, and incorporated some natural-origin adults into broodstock, it would not be expected to be substantially diverged from the natural population and thus it would be expected that the pHOS goal of less than 10 percent would reduce risks to the Sandy River natural-origin coho salmon population from hatchery-influenced selection. This is consistent with HSRG guidelines (HSRG 2009b) for a hatchery using broodstock that is integrated with the receiving natural population. However, applying the strictest definition of a segregated hatchery program to the Sandy coho salmon program, the 10 percent goal would not be considered protective enough (HSRG 2014). The HSRG (2014) identified for segregated programs that pHOS goal of 5 percent or less may be insufficient to safeguard the long-term viability of the natural-origin population.

The HSRG makes no distinction between hatchery programs using broodstock from outside the ESU/DPS and those programs that were derived from the local natural-origin population, only indicating that the impacts would be greater given the more divergence between the hatchery and natural-origin populations. This is in contrast to the ICTRT (2007a), which showed decreasing risk to the natural population depending on the source of the hatchery spawners and how the hatchery programs was operated (Figure 13). In Figure 13, above, the bottom graph would represent a hatchery program that was integrated, and the graph directly above it would represent a hatchery program that was segregated but was derived from the natural-origin population (ICTRT 2007a). For this latter group, a pHOS of 10 percent would pose a low risk to the viability of the natural population over a short period and moderate risk over the long term.

As described above for spring Chinook salmon, modeling by ODFW during development of its recovery plan identified that limiting pHOS to the less-than-10 percent goal for the Sandy River coho salmon population, along with the suite of complementary recovery actions, was shown to increase VSP parameters to the point where the Sandy River population would be viable and at very low risk of extinction (ODFW 2010a).

Furthermore, the less-than-5 percent pHOS goal that the HSRG recommends is the value that its modeling shows would limit the influence of the segregated hatchery program on the viability of the natural-origin population after many generations. The HSRG model also assumes that spawning between hatchery and natural-origin adults is completely random, where the chances

of all three types of crosses (HxH, HxN, and NxN) are equally likely to occur. If this assumption was correct, then based on the analysis of the mating-frequency in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, and in Figure 14, a pHOS level of 10 percent (0.1) should result in 81 percent of the matings being NxN, 18 percent being NxH, and 1 percent being HxH. This would ensure that a substantial majority of the matings would be NxN, which would limit impacts on the natural-origin population from hatchery-influenced selection. The actual level of HxN would probably be substantially less under the No-action Alternative because hatchery adults tend to be distributed lower in the Sandy River Basin away from the natural spawning areas.

Under the No-action Alternative, the goal is to continue to release 500,000 hatchery coho smolts annually; this is a reduction from the approximately 800,000 smolts released annually prior to 2009 (Figure 5).

Under the No-action Alternative, coho salmon production would be reared at the Sandy Hatchery, which is expected to maximize homing to the hatchery and thus, reduce straying into other areas in the Sandy River Basin. Access to the Sandy Hatchery may be delayed before fall rain increases flows in Cedar Creek, but even under these conditions, data collected at the Marmot Dam trap (ODFW 2013c) indicate that hatchery coho salmon would not stray in substantial numbers into the upper basin (Table 5). In 2012, the coho salmon pHOS was 3.0 percent (ODFW 2013c), from releases of approximately 500,000 smolts. In 2013, pHOS was 11.8 percent, from a release of 463,000 smolts. The actual impacts on the natural population indicated by 11.8 percent pHOS were likely less because the majority of the marked hatchery fish were observed in the lower Sandy River tributaries, compared to 96 percent of the estimated natural-origin spawner abundance that was in the upper basin areas where pHOS was estimated to be 5 percent. Considering this information, the adjusted pHOS would have been around 7.5 percent (). Based on available information, the risk from hatchery-influenced selection effects would pose a low risk to the natural-origin Sandy River coho salmon population under the No-action Alternative.

Weir Effects

During the operation of the Salmon, Zigzag, and Bull Run weirs, ODFW has identified that potentially up to 50 natural-origin adult coho salmon could be handled annually. In 2013, the number of adults handed at the weirs totaled 37 unmarked and 1 hatchery coho salmon (Lackey et al. 2013). Based on the mortalities observed for spring Chinook salmon during weir operations, impacts on coho salmon due to handling under the No-action Alternative, even if the maximum number are handled, are expected to be low with no more than two natural-origin coho salmon a mortalities expected annually. The weirs in the Zigzag and Salmon Rivers are expected to be removed prior to the main period of coho salmon migration and spawning and thus would not impact migration or spawning distribution.

The adult weir at the Sandy Hatchery on Cedar Creek was updated in 2012 along with modifications to the adult holding ponds in 2013. The adult weir is operated in Cedar Creek to direct all returning adult salmon and steelhead into the hatchery adult holding ponds. The adult weir is used to collect hatchery broodstock and remove surplus hatchery adults preventing them from spawning above the hatchery in Cedar Creek. Once the adults enter the holding ponds they

are sorted and all unmarked coho salmon are released above the weir and back into Cedar Creek, to spawn naturally. Under the No-action Alternative, up to 600 adult natural-origin coho salmon could be collected and handled at the Sandy Hatchery in the future. Natural-origin adult mortalities have been low with less than 10 annually. Some delay may occur because the returning adults are not sorted daily, however, the adult holding ponds provide a safe protected area to hold for the short period prior to release upstream of the weir.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery coho salmon are expected to have a negligible effect on natural-origin juveniles under the No-action Alternative.

Competition

Competition can occur when hatchery fish and the progeny of naturally spawning hatchery fish compete for rearing areas and food with fish from the local natural population(s). In the Sandy River there is little or no spatial or temporal overlap in the distribution of hatchery and natural-origin coho salmon. As described above for spring Chinook salmon, competition between hatchery and natural-origin coho salmon is expected to be minimal because hatchery coho salmon tend to segregate themselves from natural-origin fish. This was illustrated by the spawning surveys in 2013 that showed that the majority of the marked hatchery fish were observed in the lower Sandy River tributaries, compared to 96 percent of the estimated natural-origin spawner abundance that was in the upper basin areas.

Another action that is expected to mitigate the potential for competition between hatchery and natural-origin fish under the No-action Alternative is the release of all hatchery coho salmon, and winter and summer steelhead into Cedar Creek, which is located miles downstream from the majority of the preferred salmon and steelhead spawning and rearing habitats. Another action is the reduction in the annual releases of hatchery coho salmon since 2009 to the 500,000 smolts that would be released annually under the No-action Alternative.

Under the No-action Alternative, hatchery coho salmon would be released from the Sandy Hatchery adult holding pond as described in Subsection 2.1.2, Sandy River Coho Salmon Program, where observations have shown that more than 90 percent of the smolts have migrated out of the hatchery within 24 hours of providing downstream passage. Typically, hatchery salmon and steelhead smolts would emigrate quickly out of the Sandy River Basin within 21 days of the final release. As with the spring Chinook salmon program, ODFW would sample juvenile rearing areas in the lower Sandy River 21 days after the hatchery releases to determine if juvenile hatchery smolts are promptly leaving the basin as expected.

Displacement

As discussed above, the possibility of displacement due to the release of hatchery salmon and steelhead smolts was considered but rejected for two reasons. First, hatchery fish are not released into areas preferred by natural-origin fish for rearing and second, natural-origin Chinook and coho salmon and steelhead are already actively migrating to the ocean by the time they reach areas in the mainstem Sandy River where they would first encounter hatchery fish.

Predation

Predation is dependent upon many factors (Pearsons and Busack 2012), but two major prerequisites are that the predatory fish and their prey must overlap temporally and spatially, and the prey should be less than 1/3 the length of the predatory fish. Because there is little temporal or spatial overlap between hatchery smolts and natural-origin fish, there is no known threat from predation or competition under the No-action Alternative because available data show that hatchery smolts leave the system promptly and that only a small fraction remains in the system 21 days after release.

Under the No-action Alternative, those actions to minimize adverse ecological interactions between hatchery fish and natural-origin coho salmon would be implemented including releasing hatchery smolts that are physiologically ready to migrate; rearing fish to sufficient size that smoltification occurs within nearly the entire population; releasing hatchery smolts in lower river reaches, below areas used by natural-origin juveniles; and monitoring interactions.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

Under the No-action Alternative, ME&R activities would continue to monitor the Performance Indicators identified in Section 1.10 of the HGMPs, ensure compliance with the 2012 Biological Opinion (NMFS 2012b), and inform future decisions regarding how the hatchery programs can be adjusted to meet their goals while further reducing effects on ESA-listed salmon and steelhead. Minor lethal and sub-lethal effects on ESA-listed natural-origin fish are expected to occur from the handling of juveniles during the operation of the screw trap in Cedar Creek, and during the juvenile sampling in the lower mainstem Sandy River. ODFW would monitor and report annually on pHOS and the distribution of naturally spawning hatchery fish in the Sandy River and its tributaries under the No-action Alternative. Adult salmon and steelhead would also be monitored at the weirs, including the weir on Cedar Creek, and the effect on natural-origin adults is addressed above.

Under the No-action Alternative, ODFW estimates that up to 5,000 juvenile coho salmon could be handled annually during the operation of the rotary screw trap in Cedar Creek. Out of this total, an estimated 200 would die. In 2013, the first year of operation, the rotary screw trap handled 376 coho salmon and 14 steelhead smolts and 44 coho salmon fry (less than 70 mm), and 78 steelhead fry (Strobel 2014). The only mortalities were two coho salmon smolts and two coho salmon fry. The low number of mortalities is expected to have only a negligible impact on that proportion of the Sandy River coho salmon population in Cedar Creek.

Under the No-action Alternative, up to an estimated 1,000 natural-origin coho salmon juveniles would be handled during the monitoring for the presence and absence of juvenile hatchery fish in the Sandy River downstream of the Sandy Hatchery. ODFW estimates that potentially up to 30 juveniles could die from handling. An evaluation was conducted in 2013 and included sampling in the lower Sandy River below the mouth of the Bull Run River. The total number of hatchery fish observed during sampling was two steelhead smolts, no other hatchery origin juveniles were observed out of the 200 juvenile coho salmon sampled (Alsbury 2013b).

Under the No-action Alternative, masking caused by hatchery fish is not a threat to ESA-listed salmon in the Sandy River. Hatchery fish from these programs would not confuse or conceal the status of a natural population or the effects of the hatchery program on any natural population. It is expected that there would be little spatial or temporal overlap in distribution between hatchery fish and fish from natural populations in the Sandy River. In addition, hatchery fish from the four programs would be 100 percent adipose fin-clipped for easy identification. Marking and tagging of fish may well have adverse effects on the survival or viability of marked fish; however, no natural-origin fish are proposed for marking. The low level of adverse effects of marking that result from marking hatchery fish at the Sandy Hatchery would not be expected to change the number of hatchery fish available from the program.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the coho salmon hatchery program would continue to have only a negligible effect on ESA-listed species under the No-action Alternative. Under the No-action Alternative, no new construction at the Sandy Hatchery would occur and, thus, no effects would be expected from construction activities. However, maintenance of the hatchery intake and adult weir may disturb rearing juvenile salmonids. This disturbance would be expected to be minor and of short duration such that the effect would be negligible. Water intake structures and water withdrawal present another set of potential effects on listed salmonids, and these were evaluated in Subsection 4.2, Effects on Water Quality and Water Quantity.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). These effects

of fisheries targeting hatchery produced adults on the human environment are analyzed in Subsection 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

Summary of Risk Effects

Under the No-action Alternative, natural-origin Sandy River coho salmon may be adversely impacted by naturally spawning hatchery coho salmon. The 10 percent pHOS goal for the coho salmon program is not as protective of the natural-origin population against hatchery-influenced selection as the less-than-5 percent pHOS goal recommended for segregated hatchery programs by the HSRG (2009c), and even that level may be insufficient to safeguard the long-term viability of the natural-origin population (HSRG 2014). However, as described above, the 10 percent pHOS goal would be expected to reduce risks from hatchery-influenced selection effects based on the modeling that was completed by ODFW in the development of their recovery plan (ODFW 2010a). Because the hatchery program was derived from the natural-origin population, the probability that a natural-origin adult will spawn with another natural-origin adult is greater than the 81 percent, and the acclimation of smolts at the Sandy Hatchery, the potential for hatchery spring Chinook salmon to spawn with natural-origin spring Chinook salmon would be reduced.

Impacts on coho salmon would occur from the collection of broodstock, which may handle a proportion of the natural-origin adults returning to Cedar Creek as well as a small number at the weirs in the Zigzag, Salmon, and Bull Run Rivers. Impacts from handling at the hatchery and the weirs are expected to be low.

The release of hatchery salmon and steelhead may prey on juvenile coho salmon in the lower Sandy River below the Sandy Hatchery. Under the No-action Alternative, however, this impact would be expected to be low because measures would be taken to produce smolts that emigrate rapidly from the basin and to minimize the encounter rates, hatchery production would be released in areas below the primary spawning and rearing habitat, and because the smolts and juvenile salmon occupy non-overlapping habitats in the lower mainstem Sandy River.

Coho salmon are expected to benefit from the adult and juvenile passage improvements at the Sandy Hatchery intake and adult weir under the No-action Alternative. However, impacts, though minor, would occur during September, when flow would be reduced between the intake and hatchery outfall.

Spawning ground surveys would continue to be used to determine abundance and to evaluate the potential genetic impacts from hatchery coho salmon spawning naturally. Impacts on natural-origin coho salmon under the No-action Alternative from the operation of the screw trap in Cedar Creek would be expected to be low with less than an estimated 4 percent of the juveniles handled being mortalities, actual losses are substantially less than 4 percent. Data collected from the operation of the screw trap would be used to evaluate the recolonization of the habitat in Cedar Creek and contribute to determining the overall status of these species in the Sandy River Basin. Impacts on natural-origin coho salmon from monitoring the presence or absence of hatchery smolts in the lower mainstem Sandy River is expected to be low with less than 3 percent of the juveniles being lost due to handling mortality. The level of impacts under the No-

action Alternative would be expected to be low, and even reduced from levels recently observed (Subsection 3.3.2.3, Limiting Factors and Threats).

Under the No-action Alternative, reduced impacts may contribute to lowering the risk of extinction for the Sandy River coho salmon population, especially that proportion in Cedar Creek, but would not be expected to have an effect on the very high risk of extinction for the LCR Coho Salmon ESU as a whole because of limiting factors affecting the ESU outside the action area (Subsection 3.3.2.2, Status and Trends).

4.3.1.3. Sandy River Winter Steelhead

Subsection 3.3.3, Sandy River Winter Steelhead, describes populations that are part of the LCR Steelhead DPS, including the winter steelhead population in the Sandy River. Note that summer steelhead are not native to the Sandy River (Subsection 3.3.3, Sandy River Winter Steelhead). None of the steelhead populations outside the action area, nor their associated habitat, would be affected under the No-action Alternative.

Life History

The life history characteristics of the winter steelhead population in the Sandy River would not be expected to change under the No-action Alternative. As describe in Subsection 3.3.3, Sandy River Winter Steelhead, summer steelhead are not native to the Sandy River Basin, but impacts from the release of hatchery summer steelhead are analyzed for their effects on the Sandy River winter steelhead population. The winter steelhead and summer steelhead hatchery programs may impact the life history characteristics of the natural-origin winter steelhead population, but these impacts are expected to be minimal because the hatchery winter steelhead were derived from the natural-origin Sandy River winter steelhead population, and the program has incorporated natural-origin winter steelhead into the broodstock to maintain similarities between the hatchery and natural-origin winter steelhead. However, over the long term, the winter steelhead program under the No-action Alternative may impact the life history characteristics of the natural-origin winter steelhead population as a result of the hatchery winter steelhead continuing to interbreed with the natural population, which are no longer incorporated into the broodstock.

Status and Trends

The status and biological risk categories identified in Ford (2011) concluded that the LCR Steelhead DPS is at very high risk of extinction, and the Sandy River winter steelhead population was considered to also be at high to moderate risk of extinction. Under the No-action Alternative, the hatchery programs would not be expected to change the listing status and risk categories for the natural-origin winter steelhead population by the next status review, but changes to the hatchery programs that have been implemented under the No-action Alternative are expected to further reduce impacts on the natural-origin winter steelhead population. These hatchery changes along with factors affecting VSP parameters have changed since these determinations, and these changes may improve the overall status of the population over the long term. However, the hatchery program would continue to pose risks under the No-action Alternative due naturally spawning hatchery fish but these risks are minor. To the extent that adverse impacts on natural-origin winter steelhead populations under the No-action Alternative

are reduced, it is expected that the productivity of the natural-origin population would increase, leading to more adults returning to the Sandy River Basin compared to current levels (Table 5).

In Subsection 3.3.3, Sandy River Winter Steelhead, the abundance and pHOS estimates that are available for return years 2010 to 2012 were evaluated and determined to be unreliable due to small sample sizes used to determine pHOS. The 2013 and 2014 abundance estimates represent greater effort during the spawning ground surveys and this has resulted in more redds being observed and a larger sample on which to estimate pHOS. Under the No-action Alternative these spawning ground surveys would continue to provide more reliable estimates of abundance and pHOS than past surveys.

The operation of the hatchery programs under the No-action Alternative would not be expected to have any impact on spawning habitat for winter steelhead in the action area including those areas designated as critical habitat (Table 1). The specific PCEs in the action area – freshwater spawning, freshwater rearing, and freshwater migration – would not be adversely impacted by the hatchery programs, though the operation of the weir at the Sandy Hatchery would briefly delay upstream migration for natural-origin winter steelhead returning to Cedar Creek. The tributary weirs in the Zigzag, Salmon, and Bull Run Rivers would not impact the migration of winter steelhead because the weirs are not in operation when adult steelhead are returning to the basin. The effects of the removal of water for hatchery operations on rearing and migration through the bypass reach on Cedar Creek are evaluated in Subsection 4.2, Effects on Water Quality and Water Quantity.

The recovery goals for the Sandy River winter steelhead population would not change under the No-action Alternative (Subsection 1.6, Relationship to Other Plans and Policies)(ODFW 2010a; NMFS 2013c). The natural-origin Sandy River winter steelhead population, would continue to be identified as a core population with a recovery target of very high probability of persistence (less than 1 percent chance of extinction or a persistence score of 4)(Table 4). Under the No-action Alternative the recovery recommendations specific to the Sandy winter steelhead program would be implemented, as would the general recommendations for hatchery programs (ODFW 2010a; NMFS 2013c).

Summer steelhead are not indigenous and, thus, there is not a recovery goal for these fish.

Limiting Factors and Threats

Subsection 3.3.3.3, Limiting Factors and Threats, describes how McElhany et al. (2007) and ODFW (2010a) used data through 2004 to determine that the natural-origin Sandy River winter steelhead population was at high risk of extinction. The updated viability analysis determined that the effects of the changes in resource development, municipal water supply and hydropower development, and hatchery practices that have occurred since 2004 (e.g., removal of Marmot Dam and Little Sandy River diversion dam) would not have changed the determination that the natural-origin winter steelhead population in the Sandy River was at a high risk of extinction, even though, the overall status would be expected to improve as productivity increases due to reduced effects from the past use of Big Creek stock winter steelhead and from the additional habitat in the Little Sandy River and upper Cedar Creek.

The No-action Alternative would not add or detract from the effect the changes that have occurred to the impacts from resource development and municipal water supply and hydropower development, and thus their effects would continue as described in Subsection 3.3.3, Sandy River Winter Steelhead. However, the winter steelhead and summer steelhead programs are expected to have effects on the Sandy River winter steelhead population, and these effects are described below.

Effects of Hatchery Programs

In Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, NMFS identified the seven factors used to evaluate the effects of the hatchery program on the natural-origin salmon and steelhead populations. Each of these factors is reviewed below for the Sandy Hatchery winter steelhead and summer steelhead programs under the No-action Alternative.

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

Under the No-action Alternative, natural-origin winter steelhead would not be used for broodstock and, thus, there would be no effect on the natural-origin winter steelhead population.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Winter Steelhead Program

In terms of genetic risk issues, the winter steelhead hatchery program is similar to the spring Chinook salmon hatchery program. Out-of-basin winter steelhead stocks were planted into the basin for many years, and there may have been considerable introgression of genetic material from these stocks. The Sandy River natural-origin winter steelhead population may have suffered outbreeding depression as a result. However, the current program, which began with the 2000 brood year, was derived solely from the local natural-origin population, and it has incorporated natural-origin adults into the broodstock through 2011. Under the No-action Alternative, the current Sandy Hatchery winter steelhead program is not diverged from the natural population and, thus, the hatchery program has been included as part of the ESA-listed DPS (NMFS 2003a; 2004b; Jones 2011). Because of this close relationship to the natural-origin winter steelhead population, NMFS considers the Sandy River hatchery winter steelhead to be integrated with the Sandy River natural-origin winter steelhead population.

Previously, the primary method for reducing hatchery winter steelhead pHOS was to remove hatchery adults at Marmot Dam (ODFW 2013e). Under the No-action Alternative, best management practices for steelhead acclimation and release would be the primary mechanisms for achieving the pHOS goal. Acclimation and release of winter steelhead at the Sandy Hatchery has been used to reduce straying into other sections of the Sandy River and has proven successful in returning hatchery winter steelhead to Cedar Creek and the hatchery. Flows in Cedar Creek are not a hindrance or barrier to upstream fish passage for steelhead and provide easy access to the Sandy Hatchery. The recycling of hatchery winter steelhead to provide additional harvest

opportunities would continue as described in the Subsection 2.1.3, Sandy River Winter Steelhead Program, but this is not expected to pose a risk to meeting criteria for pHOS. Recycling of hatchery winter steelhead would be discontinued if monitoring shows that the 3-year moving average exceeds the less-than-10 percent pHOS goal.

Before 2013, little information was available to generate valid estimates of steelhead pHOS. Spawning ground surveys were not conducted in 2008 and 2009, and only minimal or limited surveys were conducted in 2010, 2011, and 2012. Abundance and pHOS estimates were based on small sample sizes and therefore of limited value. For example, the 2010 pHOS estimate of 29 percent was based on seven live adults being observed with two being clipped. Moreover, one of the two marked fish was observed above the mouth of Cedar Creek and the other was observed below, meaning that both of these steelhead could have returned to hatchery rather than spawning naturally (Schroeder 2013). The 2011 and 2012 estimates of 0 percent pHOS were based on 19 and 3 live winter steelhead observed, all with adipose fins. NMFS does not believe that pHOS was 0. In 2013, the sampling and spawning survey program was expanded to increase sample sizes (i.e., the number of known-mark adults that were observed), and this would result in greater confidence in the accuracy of the pHOS and abundance estimates. Data for 2013 indicate that the total runsize was 3,747 adults of which 3,509 were natural-origin and 238 were hatchery origin (ODFW 2013e). The pHOS estimate of 6.4 percent was based on a sample size of 47 observed known-mark winter steelhead. Preliminary estimates for 2014 indicate that the runsize was 3,316 naturally spawning adults, and that 3,217 of these were natural-origin winter steelhead (Table 5). The pHOS was estimated to be 3 percent, well below the less-than-10 percent pHOS goal.

As described above for coho salmon, the HSRG (2014) identified that pHOS should be 5 percent or less for a segregated program, however, HSRG stated that even this level of pHOS may be insufficient to safeguard the long-term viability of the natural-origin population. The HSRG makes no distinction between hatchery programs using broodstock from outside the ESU/DPS and those programs that were derived from the local natural-origin population (such as the Sandy River winter steelhead program), only indicating that the impacts would be greater as the divergence between the hatchery and natural-origin populations increases. This is in contrast to the ICTRT (2007a) which showed decreasing risk to the natural population depending on the source of the hatchery spawners and how the hatchery programs was operated (Figure 13). In Figure 13, the bottom graph would represent a hatchery program that was integrated, and the graph directly above that would represent a hatchery program that was segregated but was derived from the natural-origin population (ICTRT 2007a). For this latter group, a pHOS of 10 percent would pose a low risk to the viability of the natural population over a short period and moderate risk over the long term.

As described above for spring Chinook salmon, modeling by ODFW during the development of its recovery plan identified that limiting pHOS to the less-than-10 percent goal for the Sandy River winter steelhead population, along with the suite of complementary recovery actions, was shown to increase VSP parameters to the point where the Sandy River population would be viable and at very low risk of extinction (ODFW 2010a).

Furthermore, the less-than-5 percent pHOS goal that the HSRG recommends is the value that modeling shows would limit the influence of the segregated hatchery program on the viability of the natural-origin population after many generations. The HSRG model also assumes that spawning between hatchery and natural-origin adults is completely random, where the chances of all three types of crosses (HxH, HxN, and NxN) are equally likely to occur. If this assumption is correct, then based on the analysis of the mating-frequency in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, and in Figure 14, a pHOS level of 10 percent (0.1) should result in 81 percent of the matings being NxN, 18 percent being NxH, and 1 percent being HxH. This would ensure that the vast majority of the matings would be NxN, which would limit impacts on the natural-origin population from hatchery-influenced selection. The actual level of HxN would probably be substantially less under the No-action Alternative because hatchery adults tend to be distributed lower in the Sandy River Basin, away from the natural spawning areas.

ODFW would continue monitor escapement of natural-origin winter steelhead that are passed above the hatchery to spawn naturally in upper Cedar Creek under the No-action Alternative. After the release in 2012 of 34 natural-origin and 334 hatchery winter steelhead above the hatchery, ODFW reduced the hatchery proportion to less than 50 percent in 2013 when 12 hatchery winter steelhead and 20 natural-origin winter steelhead were released above the weir. There is some concern that, at this low level of escapement, demographic effects (e.g., not finding mates, low effective population size) may reduce the productivity of this subgroup of winter steelhead. However, in 2014, it was decided that for a period of 5 years ending in 2019, under the No-action Alternative, only unmarked winter steelhead would be passed above the hatchery. In 2014, 24 natural-origin adults and no hatchery winter steelhead were passed above the hatchery. Over time, the effects of these releases on productivity in Cedar Creek would be monitored using a rotary screw trap to collect juvenile outmigrants.

Summer Steelhead Program

The No-action Alternative includes an segregated summer steelhead program. The hatchery program does not include genetic resources representing the genetic legacy of the LCR steelhead DPS and, thus, is not included in the DPS. Hatchery summer steelhead originate from a well-established, highly domesticated broodstock and are collected at the South Santiam Hatchery. This category of hatchery program poses the greatest risk to natural steelhead populations, and for that reason, the No-action Alternative includes a pHOS goal of less than 5 percent, based on a 3-year moving average. Based on best available information, NMFS concludes that this pHOS goal can and would be met, and poses a low risk to the natural-origin Sandy River winter steelhead population. To further support this conclusion, there is little overlap between the natural spawn timing of the hatchery summer steelhead and the natural-origin winter steelhead population. Summer steelhead spawning at the Santiam Hatchery is generally completed by the end of February, which is before the time when Sandy River winter steelhead spawning generally commences. This separation in spawn timing between hatchery summer steelhead and winter steelhead was confirmed by research that showed that interbreeding between summer and winter steelhead is minimal even at high summer steelhead abundances (Leider et al. 1984; Kostow et al. 2003). In addition, there is little evidence of reproductive success of summer steelhead in the Sandy River Basin; natural-origin summer steelhead are rarely encountered at the weirs in the upper basin.

Additional management measures or best management practices included under the No-action Alternative to limit pHOS include the acclimation and release summer steelhead smolts at the Sandy Hatchery to encourage their return to the hatchery rather than the spawning grounds, 100 percent adipose fin-clipping that would allow positive identification and removal, using fisheries and weir operations to remove escaping summer steelhead, and limiting the hatchery release to 75,000 smolts annually. These practices and management actions, combined with the differences in natural spawn timing between hatchery summer steelhead and natural-origin winter steelhead, would ensure that the pHOS goal would continue to be met under the No-action Alternative. The recycling of hatchery summer steelhead to provide additional harvest opportunities would continue as described in Subsection 2.1.4, Sandy River Summer Steelhead Program, but only if annual monitoring shows that 3-year moving average for pHOS is less than 5 percent.

Compared to salmon, steelhead are difficult to enumerate on the spawning grounds because of their protracted spawning period and because of the typical conditions during the natural spawning period, for example high flows and high turbidity and low visibility make visual observations difficult. The methodology used for estimating summer steelhead pHOS in the Sandy River is thought to provide conservative estimates (Subsection 4.3, Effects on Anadromous Fish Listed under the ESA), that is, it is more likely to overestimate than under estimate summer steelhead pHOS. Furthermore, ODFW, when conducting coho salmon spawning surveys from October through January, also reports steelhead observations, both live adults and redds. It is instructive and important to note that few steelhead have been observed during the coho salmon surveys even though around 56 percent of the habitat surveyed during coho spawning surveys overlaps with winter steelhead spawning habitat. These surveys provide on-the-ground observations resulting in information on whether or not summer steelhead are spawning prior to the month of February and constitute the best available information for monitoring compliance with the less-than-5 percent summer steelhead pHOS goal. Based on the most recent survey information, the summer steelhead pHOS goal under the No-action Alternative would likely be met and, therefore, genetic effects from this level of pHOS would pose a low risk to natural-origin Sandy River winter steelhead population under the No-action Alternative.

Weir Effects

The weirs, if installed by the first of June, may encounter winter steelhead kelts (fish that have already spawned) leaving freshwater for the ocean. The number of kelts that could be encountered is unknown but expected to be low because winter steelhead spawning is usually completed by early May, reducing the potential for kelts to be present when the weirs are installed. Adult winter steelhead returning to the river to spawn would not be encountered during weir operations because they return after the weirs are removed and before they are installed again the following season. As result any effect is expected to be negligible. No kelts were encountered during weir operations in 2012 and 2013 (Lackey et al. 2013; Zweifel 2013).

During the operation of the Salmon, Zigzag, and Bull Run weirs, ODFW has identified that potentially up to 200 adult unmarked summer steelhead could be handled annually. As described in Subsection 2.1.1, Sandy River Spring Chinook Salmon Program, unmarked summer steelhead that are encountered at the weirs would be passed upstream of the weirs to continue their

migration. In 2013, the number of adults handed at the weirs totaled 20 unmarked summer steelhead (of that total, 16 unmarked and one known hatchery summer steelhead were recovered at the Bull Run weir)(Lackey et al. 2013). The unmarked summer steelhead that are collected at the Bull Run weir were tissue-sampled to determine their origin. Applying the mortality rate observed for spring Chinook salmon during weir operations to steelhead, impacts on unmarked summer steelhead due to handling, even if the maximum number are handled, are expected to result in no more than five unmarked summer steelhead mortalities annually.

The adult weir at the Sandy Hatchery on Cedar Creek was updated in 2012 along with modifications to the adult holding ponds in 2013. Under the No-action Alternative, the adult weir would be operated in Cedar Creek to direct all returning adult salmon and steelhead into the hatchery adult holding ponds. The adult weir is used to collect hatchery broodstock and to remove surplus hatchery adults preventing them from spawning above the hatchery in Cedar Creek. Once the adults enter the holding ponds they are sorted, and all unmarked winter steelhead are released above the weir and back into Cedar Creek, to spawn naturally. Any unmarked summer steelhead collected at the hatchery would be released back into the Sandy River. The No-action Alternative estimates that up to 200 adult natural-origin winter steelhead could be collected and handled at the Sandy Hatchery in the future. Natural-origin adult mortalities have been low with less than 10 annually. Some delay may occur because the returning adults are not sorted daily, however, the adult holding ponds provide a safe protected area to hold for the short period prior to release upstream of the weir.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery steelhead are expected to have a negligible effect on natural-origin juveniles.

Competition

Under the No-action Alternative, the effects from competition between hatchery salmon and steelhead and natural-origin winter steelhead in the action area would the same as those described in Subsection 4.3.1.2, Sandy River Coho Salmon, and expected to be minor because hatchery and natural-origin fish tend to spatially segregate in the natural habitat, most of the natural spawning and rearing habitat is the upper basin located above the hatchery release locations, natural-origin steelhead tend to have protracted outmigration, whereas the hatchery releases tend to emigrate quickly, and because the hatchery juveniles are reared such they are uniform in size and condition to ensure that they are fully smolted (what to migrate to the ocean) prior to release. To ensure that the hatchery smolts emigrate quickly, limiting the potential to interact with the natural-origin winter steelhead, under the No-action Alternative, ODFW would monitor for the presence of hatchery smolts in the lower Sandy River.

Displacement

The displacement of natural-origin winter steelhead in the Sandy River due to the release of hatchery salmon and steelhead was not considered an effect because hatchery fish are not released into areas preferred by natural-origin fish for rearing. Further, natural-origin steelhead are already actively migrating to the ocean by the time they reach areas in the mainstem Sandy River where the hatchery fish are released.

Predation

Predation is dependent upon many factors (Pearsons and Busack 2012), but two major prerequisites are that the predatory fish and their prey must overlap temporally and spatially, and the prey should be less than 1/3 the length of the predatory fish. Impacts on natural-origin fish from hatchery summer steelhead smolts are expected to be minor because there is little temporal or spatial overlap between hatchery smolts and natural-origin fish. Under the No-action Alternative, ODFW would continue to monitor for the presence or absence of hatchery fish in the lower Sandy River to determine if interactions might be occurring.

Under the No-action Alternative, those actions to minimize adverse ecological interactions between hatchery fish and natural-origin winter steelhead would be implemented including releasing hatchery smolts that are physiologically ready to migrate; rearing fish to sufficient size that smoltification occurs within nearly the entire population; releasing hatchery smolts in lower river reaches, below areas used by natural-origin juveniles; and monitoring interactions.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

Under the No-action Alternative, ME&R activities would continue to monitor the Performance Indicators identified in Section 1.10 of the HGMPs, ensure compliance with the 2012 Biological Opinion (NMFS 2012b), and inform future decisions regarding how the hatchery programs can be adjusted to meet their goals while further reducing effects on ESA-listed salmon and steelhead. Minor lethal and sub-lethal effects on ESA-listed natural-origin fish are expected to occur from the handling of juveniles during the operation of the screw trap in Cedar Creek, and during the juvenile sampling in the lower mainstem Sandy River. ODFW would monitor and report annually on pHOS and the distribution of naturally spawning hatchery fish in the Sandy River and its tributaries. Adult salmon and steelhead would also be monitored at the weirs, including the weir on Cedar Creek, and the effect on natural-origin adults is addressed above.

Under the No-action Alternative, ODFW estimates that up to 3,500 juvenile winter steelhead could be handled annually during the operation of the rotary screw trap in Cedar Creek. Out of

this total an estimated 35 would be mortalities. In 2013, the first year of operation, the rotary screw trap handled 376 coho salmon and 14 steelhead smolts and 44 coho salmon fry (less than 70 mm), and 78 steelhead fry (Strobel 2014). The only mortalities were two coho salmon smolts and two coho salmon fry. The low mortality rate is expected to have only a negligible impact on that proportion of the Sandy River winter steelhead population in Cedar Creek. The information provided on natural production and productivity may be applicable to the rest of the population during the analysis of VSP parameters.

Under the No-action Alternative, up to an estimated 100 natural-origin winter steelhead juveniles would be handled during the monitoring for the presence and absence of juvenile hatchery fish in the Sandy River downstream of the Sandy Hatchery. ODFW estimates that potentially up to three juveniles could die from handling. The first evaluation was conducted in 2013 and included sampling in the lower Sandy River below the mouth of the Bull Run River. The total number of hatchery fish observed during sampling was two steelhead smolts; no other hatchery origin juveniles were observed (Alsbury 2013b).

Under the No-action Alternative, masking caused by hatchery fish is not a threat to ESA-listed salmon in the Sandy River. Hatchery fish from these programs would not confuse or conceal the status of a natural population or the effects of the hatchery program on any natural population. It is expected that there would be little spatial or temporal overlap in distribution between hatchery fish and fish from natural populations in the Sandy River. In addition, hatchery fish from the four programs would be 100 percent adipose fin-clipped for easy identification. Marking and tagging of fish may have adverse effects on the survival or viability of marked fish, but such effects are not analyzed here, as no natural-origin fish are proposed for marking.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the winter steelhead hatchery program would continue to have a negligible effect on ESA-listed species under the No-action Alternative. Under the No-action Alternative, no new construction at the Sandy Hatchery would occur and thus, no effects would be expected. Water intake structures and water withdrawal present another set of potential effects on listed salmonids, and these were evaluated in Subsection 4.2, Effects on Water Quality and Quantity.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). These effects of fisheries targeting hatchery produced adults on the human environment are analyzed in Subsections 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

Summary of Risks

Under the No-action Alternative, natural-origin Sandy River winter steelhead may be adversely impacted by naturally spawning hatchery steelhead from both winter and summer steelhead programs. Basin-wide spawning surveys have observed that the proportion of hatchery winter steelhead spawning naturally can be greater than the 10 percent goal established in the recovery plans (ODFW 2010a; NMFS 2013c). However, pHOS estimates for return years 2010 to 2012 were unreliable due to the small sample size used to estimate pHOS. More accurate estimates have resulted from more intensive spawning ground surveys, which have indicated that pHOS for winter steelhead is less than the 10 percent goal. By maintaining the pHOS goal of less than 10 percent, potential effects from hatchery-influenced selection are expected to be low because the hatchery winter steelhead program was derived from the natural-origin Sandy River winter steelhead population, and had incorporated natural-origin adults into the broodstock until 2011, therefore, the hatchery winter steelhead would not be expected to have diverged to the degree that would adversely affect the natural population if less than 10 percent of the naturally spawning population were of hatchery origin.

However, as the winter steelhead hatchery program continues to use only returning hatchery adults for broodstock, the risk from hatchery-influenced selection effects may increase because the pHOS goal of 10 percent exceeds the 5 percent goal recommended for segregated programs by the HSRG (2014), and even this level may be insufficient to safeguard long-term viability of the natural-origin population. As discussed above (under Factor 2), risks from hatchery-influenced selection would be expected to remain low primarily because of the factors listed above.

Potential genetic impacts from the naturally spawning hatchery summer steelhead are extremely low because of the differences in spawning time between the hatchery summer steelhead and natural-origin winter steelhead, and the low numbers of summer steelhead observed in the upper Sandy River Basin.

Impacts on winter steelhead would occur from the collection of broodstock, which may handle a proportion of the natural-origin adults returning to Cedar Creek (winter steelhead have not been and would not be expected to be encountered at the other tributary weirs). Impacts from handling at the hatchery are expected to be low.

The release of hatchery salmon and steelhead may prey on juvenile winter steelhead in the lower Sandy River below the Sandy Hatchery; however, this impact would be expected to be low because of the actions taken to produce smolts that emigrate rapidly from the basin, minimizing the encounter rates, hatchery production would be released in areas below the primary spawning and rearing habitat, and the hatchery smolts and juvenile winter steelhead occupy non-overlapping habitats in the lower mainstem Sandy River.

Winter steelhead are expected to benefit from the adult and juvenile passage improvements at the Sandy Hatchery intake and adult weir. But impacts would occur during September when flow would be reduced between the intake and hatchery outfall.

Spawning ground surveys would continue to be used to determine abundance and to evaluate the potential genetic impacts from hatchery steelhead spawning naturally. Impacts on natural-origin winter steelhead from the operation of the screw trap in Cedar Creek would be expected to be low, with less than 2 percent of the juveniles being lost – observed losses are substantially less than 2 percent. Data collected from the operation of the screw trap would be used to evaluate the recolonization of the habitat in Cedar Creek and contribute to determining the overall status of these species in the Sandy River Basin. Impacts on natural-origin winter steelhead from monitoring the presence or absence of hatchery smolts in the lower mainstem Sandy River is expected to be low with less than 3 percent of the juveniles being lost. The level of adverse impacts under the No-action Alternative on natural-origin winter steelhead is unknown, but would be expected to be low, and possibly reduced from adverse levels recently observed.

4.3.1.4. Columbia River Chum Salmon

Life History

The presence of hatchery programs under the No-action Alternative would be expected to have no effect on Sandy River chum salmon, and its life history, because chum salmon are not currently present in the Sandy River. In the future, if chum salmon are reintroduced or recolonize habitat in the Sandy River, the hatchery programs under the No-action Alternative would be expected to impact chum salmon. As described in Subsection 3.3.4, Columbia River Chum Salmon, the survival and growth in juvenile chum salmon depends less on freshwater conditions than on favorable estuarine and ocean conditions. These factors are outside the action area and would not be affected by the hatchery programs.

Status and Trends

Columbia River chum salmon have been extirpated from the Sandy River Basin. No actions have been identified to actively reintroduce chum salmon into the basin.

Limiting Factors and Threats

Within the Sandy River, the Recovery Plan (ODFW (2010a)) identified the secondary limiting factors as including impaired upstream passage, altered hydrology, and excessive fine sediment limiting the viability of the natural population. Barriers at road crossings, including culverts on Beaver and Buck Creeks in the lower Sandy River watershed, could impede chum salmon passage in several lower Sandy River tributaries. The hatchery programs under the No-action Alternative would have no effect on these limiting factors. Critical habitat was designated for the Columbia River Chum Salmon ESU, but did not include the Sandy River Basin (Table 1); therefore, no adverse effects on critical habitat would occur under the No-action Alternative.

The recovery goal for the Sandy River population of chum salmon, as described in the Recovery Plan (ODFW 2010a), is for the population to be at low risk of extinction (less than 5 percent probability). An annual abundance goal was not established for this population. There are no specific hatchery actions to address impacts of the Sandy River Hatchery programs on chum salmon, other than improving passage at the hatchery intake and adult weir on Cedar Creek, which has been completed.

If chum salmon were present in the Sandy River, impacts could occur as a result of the No-action Alternative from interactions with juvenile hatchery fish. The effect of these impacts on the ESA-listed chum salmon is expected to be negligible because ODFW would implement the following BMPs under the No-action Alternative so that hatchery fish move quickly out of the Sandy River Basin. These BMPs include rearing juveniles to the sizes and under conditions identified in the HGMPs, i.e., continuing to mark all hatchery juveniles, and acclimating hatchery juveniles prior to release. In addition, ODFW would verify with monitoring the presence of hatchery juveniles in the lower Sandy River as part of the juvenile outmigration monitoring; ODFW would provide reports of the results to NMFS annually.

4.3.1.5. Pacific Eulachon

Life History

The presence of hatchery programs under the No-action Alternative would be expected to have an impact on eulachon in the Sandy River, but this impact would likely be low, and would not be expected to affect the life history characteristics Pacific eulachon.

Under the No-action Alternative, designated critical habitat in the action area would not likely be affected because it is limited to the lower below the mouth of Gordon Creek (RM 12.8). Gordon Creek enters the Sandy River at Oxbow Park (Figure 1), and all of the facilities associated with the hatchery programs are located in the Sandy River well above the mouth of Gordon Creek; thus, the activities under the No-action Alternative would not be expected to impact Pacific eulachon habitat.

Status and Trends

Eulachon abundance is at or near, historically low levels throughout their range, including the Sandy River (Subsection 3.3.5, Pacific Eulachon). Hatchery programs under the No-action Alternative would not be expected to affect these abundance levels because predation of juvenile eulachon by natural or hatchery salmon and steelhead juveniles was not identified as a factor limiting the abundance or distribution of eulachon.

Limiting Factors and Threats

Because of the overlap in the lower Sandy River Basin between the emergence of juvenile eulachon in January through March and the release of hatchery juveniles from March through May, there would be a potential for predation on and competition with eulachon by hatchery salmonids juveniles under the No-action Alternative. Presently, information regarding the predation on juvenile eulachon by juvenile salmonids is non-existent. Predation by juvenile salmonids may occur, but would be limited by hatchery actions designed to produce actively migrating smolts and by the small size and transparency of the emergent eulachon fry, the distribution of eulachon fry in the water column, and the rapid emigration of eulachon juveniles from the lower Sandy River (generally downstream of Gordon Creek at RM 12.8) (Gustafson et al. 2010) – for these same reasons, competition would not be expected.

Competition between adult eulachon and juvenile salmonids may occur when food preferences overlap in the estuary and ocean environment, but impacts are expected to be low. The potential exists for salmonids to prey on adult eulachon, but data on impacts is non-existent, and predation by salmonids was not considered to be a limiting factor (Gustafson et al. 2010).

4.3.1.6. Bull Trout

As described in Subsection 3.3.6, Bull Trout, the presence of bull trout in the Sandy River has been in the form of adult fish foraging in the basin during the winter months. Under the No-action Alternative, the operation of the hatchery programs would have no effect on bull trout core areas or critical habitat since these are not found in the Sandy River Basin (USFWS 2014). Bull trout would not be expected to be handled at the weirs because the weirs would not be operated in the winter when adult bull trout have been observed in the Sandy River. No bull trout have been handled at that Sandy Hatchery weir even though it has been operated during the winter to collect coho and winter steelhead. Bull trout may benefit under the No-action Alternative from the presence of hatchery adult carcasses (i.e., from naturally spawning hatchery fish or outplanted carcasses), which is a food source for bull trout, though the actual level of benefit is expected to be low (USFWS 2002).

4.3.2. Alternative 2 (No Hatchery) – Do Not Approve the HGMPs under Limit 5 of the 4(d) Rule

Under this alternative, it is assumed that, with the termination of the hatchery programs, the adult weir and intake structures at the Sandy Hatchery would be removed or modified to all voluntary passage, and the tributary weirs described under the No-action Alternative would not be installed or operated.

4.3.2.1. Sandy River Spring Chinook Salmon

The lack of hatchery programs under the No-hatchery Alternative would be expected to have an overall beneficial effect on the three Chinook populations in the Sandy River because any impacts from the hatchery programs currently operating in the basin would be eliminated, and because eliminating the hatchery would not deprive those populations of any benefits on which they depend.

Life History

The life history characteristics of the three Chinook salmon populations in the Sandy River would not be expected to change under the No-hatchery Alternative. For the tule fall Chinook salmon and late-fall Chinook salmon populations, the life-histories would not be expected to change under the No-hatchery Alternative because there would be minimal, if any, effect on these run-types from the current hatchery programs under the No-action Alternative (Subsection 3.3.1, Sandy River Spring Chinook Salmon). The spring Chinook salmon hatchery program may impact the life history characteristics of the natural-origin spring Chinook salmon population under the No-action Alternative, and these impacts would not be expected to occur under the No-hatchery Alternative. However, these impacts are expected to be minimal because the hatchery spring Chinook salmon were derived from the natural-origin Sandy River spring Chinook salmon

population, and the program has incorporated natural-origin spring Chinook salmon into the broodstock to maintain similarities between the hatchery and natural-origin spring Chinook salmon. However, over the long term, the spring Chinook salmon program under the No-action Alternative may impact the life history characteristics of the natural-origin spring Chinook salmon population because natural-origin spring Chinook salmon are no longer used for broodstock and as a result of the hatchery spring Chinook salmon continuing to interbreed with the natural population. These impacts would not occur under the No-hatchery Alternative because the hatchery program would not be operated.

Status and Trends

The ESA-listing status and risk categories for the three natural-origin Chinook salmon populations in the Sandy River Basin would not be expected to change under the No-hatchery Alternative, similar to the No-action Alternative. For comparison, impacts from the hatchery programs under the No-action Alternative would not be expected to change risk categories for the tule fall Chinook salmon population or the late fall Chinook salmon population because impacts from the hatchery programs would be minor, and the majority of the limiting factors for these populations would not be affected by the hatchery programs. However, under the No-hatchery Alternative, these impacts would not be expected to occur. The listing status and risk categories for the natural-origin spring Chinook salmon population would not be expected to change by next status review, but changes to the hatchery programs that have been implemented under the No-action Alternative are expected to further reduce impacts on the natural-origin spring Chinook salmon population. The effect of these hatchery changes under the No-action Alternative would continue under the No-hatchery Alternative until all of the hatchery spring Chinook salmon released in the recent past had returned to the Sandy River, after which these effects would not occur.

However, spring Chinook, tule fall Chinook, and late-run fall Chinook salmon straying from outside the action area would remain at levels simlar to what is now observed for the No-action Alternative. Under the No-hatchery Alternative, the straying of Sandy Hatchery spring Chinook salmon into the natural spawning areas in the upper basin could substantially increase, elevating the risk of hatchery-influenced selection. This increase could occur for a period of up to 5 years immediately following the closure of the hatchery because the weirs and trapping operations that currently remove hatchery spring Chinook salmon would not be operated.

The recovery goal for the Sandy River spring Chinook salmon population would not change under the No-hatchery Alternative, the same as under the No-action Alternative (Subsection 1.6, Relationship to Other Plans and Policies) (ODFW 2010a; NMFS 2013c). The natural-origin Sandy River spring Chinook salmon population would continue to be identified as a core and genetic legacy population with a recovery target of high probability of persistence (score of 3). Under the No-hatchery Alternative, the recovery recommendations specific to the Sandy spring Chinook salmon hatchery program would not be implemented, nor would the general recommendations for hatchery programs, because the hatchery program would be terminated.

The minor impacts from operation of the hatchery programs under the No-action Alternative on anchor habitat or spawning areas for Sandy River spring Chinook salmon though the operation of the weirs in the Zigzag River and Salmon River would not occur under the No-hatchery

Alternative because the tributary weirs would not be operated. Under the No-hatchery Alternative, those essential physical and biological features affecting freshwater spawning, freshwater rearing, and freshwater migration that were designated as critical habitat for the LCR Chinook Salmon ESU in the action area would not be affected by hatchery operations, weirs, or intake structures (Subsection 3.3.1, Sandy River Spring Chinook Salmon).

Limiting Factors and Threats

As under the No-action Alternative, the No-hatchery Alternative would not add or detract from the effect the changes that have occurred to the impacts from resource development and municipal water supply and hydropower development since 2004 and thus, their effects would continue as described in Subsection 3.3.1, Sandy River Spring Chinook Salmon. However, the effects of the spring Chinook salmon program on the Sandy River spring Chinook salmon population would not be expected to occur because the hatchery program would be terminated.

Effects of Hatchery Programs

The seven factors used to evaluate the effects of hatchery programs on the natural-origin populations identified in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, are reviewed below under the No-hatchery Alternative with impacts comparisons to the No-action Alternative.

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

Under the No-action Alternative and the No-hatchery Alternative, natural-origin spring Chinook salmon would not be used for broodstock and thus, there would be no effect on the natural-origin spring Chinook salmon population.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential impacts from genetic effects are described under Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. The elimination of the proposed spring Chinook salmon program under the No-action Alternative would eventually reduce the number of hatchery adults that could potentially interbreed with natural-origin adults, reducing or eliminating genetic impacts (e.g., outbreeding effects, hatchery-influenced selection) on the natural spring Chinook salmon population in the Sandy River. If the spring Chinook salmon hatchery program is eliminated, as would occur under the No-hatchery Alternative, hatchery adults that remain in the marine environment would be expected to return over 2 to 5 years, contributing to the number of hatchery adults that could potentially interbreed with the natural-origin spring Chinook salmon population in the Sandy River.

Potential impacts from the operation of weirs would not occur under the No-hatchery Alternative. Weir rejection resulting in changes in spawning distribution, migration delay affecting spawn timing, and delayed mortality from handling at the weirs would not occur under

the No-hatchery Alternative because the weirs would not be operated to collect broodstock and to remove hatchery adults. Straying of hatchery adults from other programs could occur under the No-hatchery Alternative, as observed for the tule fall Chinook salmon population in the Sandy River, and would result in increased effects on the natural-origin population because the weirs would not be operated to remove strays, but would be expected to be at levels below the 10 percent goal established in the recovery plans (ODFW 2010a; NMFS 2013c).

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery spring Chinook salmon are expected to have a negligible effect on natural-origin juveniles under the No-action Alternative.

The potential impacts from ecological interactions under the No-action Alternative would occur where hatchery smolts interact with natural-origin juveniles during the downstream migration, and if hatchery juveniles residualize and do not emigrate. In contrast, the potential impacts from competition between hatchery juveniles, the progeny of naturally spawning hatchery fish, and natural-origin juveniles in the action area would not be expected to occur under the No-hatchery Alternative because hatchery juveniles would no longer be released into the Sandy River Basin, and juvenile fish from outside the action area would not be expected to move into the Sandy River Basin.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, this factor is not a threat. Under the No-hatchery Alternative, any potential density-dependent effects in the migration corridor from the release of hatchery fish in the Sandy River would not be expected to occur because juvenile hatchery fish would no longer be released in the Sandy River Basin.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

Under the No-hatchery Alternative, ME&R activities that would evaluate the hatchery programs would not be expected to continue (e.g., hatchery juvenile presence and absence in lower mainstem Sandy River). However, monitoring and evaluation activities (e.g., spawning ground surveys) in the Sandy River Basin to monitor the status and recovery of the listed populations in the basin (Subsection 2.1.2, Sandy River Coho Salmon Program) and as part of the Bull Run Water Supply HCP (e.g., juvenile abundance monitoring) would be expected to continue (Subsection 1.6, Relationship to Other Plans and Policies) (NMFS 2008b).

These monitoring and evaluations activities would continue to impact listed species under the No-hatchery Alternative due to the handling of listed adults and juveniles and from the operation of a screw trap in Cedar Creek to monitor the recolonization of habitat above the Sandy Hatchery and from other monitoring and evaluation activities that would occur annually. All of these activities would be consistent with the general guidelines developed by NMFS to reduce impacts when collecting adults and juveniles, but impacts from handling would be expected to occur identically under all action alternatives.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the spring Chinook salmon hatchery program would continue to have a negligible effect on ESA-listed species under the No-action Alternative. Under the No-hatchery Alternative, no new construction at the Sandy Hatchery would occur and thus, no effects would be expected. As described in Subsection 4.2, Effects on Water Quality and Water Quantity, if the hatchery programs are terminated, then the intake structures and adult weir would no longer be operated. Under such a scenario the adult weir would be lowered to allow for unimpeded passage and the water that would have been removed under the No-action Alternative would remain in Cedar Creek. The passage facilities at the intake structure would continue to operate allowing upstream and downstream passage past the facility.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The release of hatchery fish to support these fisheries would not occur under the No-hatchery Alternative thus, eliminating those fisheries that would target these fish in the Sandy River Basin. The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsection 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

4.3.2.2. Sandy River Coho Salmon

The lack of hatchery programs under the No-hatchery Alternative would be expected to have a beneficial effect on the natural-origin populations in the Sandy River because any impacts of the hatchery programs currently operating in the basin would be eliminated and there are no beneficial effects to the natural-origin population from the hatchery program. Subsection 3.3.2, Sandy River Coho Salmon, describes populations that are part of the LCR Coho Salmon ESU including the Sandy River coho salmon population. All of the other coho salmon populations and their associated habitat reside outside the action area and would not be affected under the No-hatchery Alternative.

Life History

Under the No-action Alternative, impacts on the life history of the coho salmon population in the Sandy River would not be expected to occur. Under the No-action Alternative, the hatchery coho salmon program could impact the life history characteristics of the natural-origin coho salmon population, but these impacts are expected to be minimal over the near term because NMFS (2003a) determined that the Sandy River hatchery coho salmon program was no more than moderately diverged from the natural population in the watershed and that the stock was derived from the local, natural-origin population. However, over the long term, the coho salmon program under the No-action Alternative may impact the life history characteristics of the natural-origin coho salmon population because natural-origin coho salmon are not used for broodstock and as a result of the hatchery coho salmon continuing to interbreed with the natural population even at a low level. Under the No-hatchery Alternative this effect would not occur because the hatchery program would be terminated.

Status and Trends

The status and biological risk categories identified in Ford (2011) concluded that the LCR Coho Salmon ESU is at very high risk of extinction; however, the Sandy River coho salmon population was considered to be at high to moderate risk of extinction. ODFW (2010a) determined that the Sandy River coho salmon population abundance and productivity parameter had decreased relative to that observed by McElhany et al. (2007), and this contributed to the lowering of the overall status to high risk (Figure 8). To the extent that adverse impacts on Sandy River coho salmon populations under the No-hatchery Alternative reduces impacts relative to the No-action Alternative, it would be expected that the productivity of the natural-origin population would increase, leading to more adults returning to the Sandy River basin compared to current levels (Table 5). The effect of these hatchery changes under the No-action Alternative would continue under the No-hatchery Alternative until all of the hatchery coho salmon released in the recent past had returned to the Sandy River, after which these effects would not occur.

The recovery goal for the Sandy River coho salmon population would not change under the No-hatchery Alternative as under the No-action Alternative (Subsection 1.6, Relationship to Other Plans and Policies) (ODFW 2010a; NMFS 2013c). The natural-origin Sandy River coho salmon population would continue to be identified as key to recovery of the Cascade coho salmon strata and the LCR coho salmon ESU with a target of high probability of persistence (score of 3).

The operation of the hatchery programs under the No-action Alternative would not be expected to have any impact on the anchor habitat or spawning areas for Sandy River coho salmon though the operation of the tributary weirs and the adult weir at the Sandy Hatchery may adversely impact the natural-origin coho salmon population. These weir effects would not occur under the No-hatchery Alternative.

Limiting Factors and Threats

As under the No-action Alternative, the No-hatchery Alternative would not add or detract from the effect the changes that have occurred since 2004 to the impacts from resource development and municipal water supply and hydropower development and thus, their effects would continue

as described in Subsection 3.3.2.3, Limiting Factors and Threats. However, impacts from the coho salmon program on the Sandy River coho salmon population would not be expected to occur because the hatchery program would be terminated.

Effects of Hatchery Programs

The seven factors used to evaluate the effects of hatchery programs on the natural-origin populations identified in Subsection 4.1, Potential Hatchery Effects, are reviewed below under the No-hatchery Alternative with comparisons to the No-action Alternative.

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

Under the No-action Alternative and the No-hatchery Alternative, natural-origin coho salmon would not be used for broodstock and thus there would be no effect on the natural-origin coho salmon population.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential impacts from genetic effects are described under Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. The elimination of the proposed coho salmon program under the No-hatchery Alternative would eventually reduce the number of hatchery adults that could potentially interbreed with natural-origin adults, reducing or eliminating genetic impacts (e.g., outbreeding effects, hatchery-influenced selection) on the natural coho salmon population in the Sandy River. If the coho salmon hatchery program is eliminated, as would occur under the No-hatchery Alternative, hatchery adults that remain in the marine environment would be expected to return over the following 2 years, contributing to the number of hatchery adults that could potentially interbreed with the natural-origin coho salmon population in the Sandy River. Straying of hatchery adults from other programs could occur, but would be expected to be at levels below the 10 percent goal established in the recovery plans (ODFW 2010a; NMFS 2013c).

Potential impacts from the operation of weirs would not occur under the No-hatchery Alternative. Mortality from trapping and handling coho salmon at the tributary weirs and at the Sandy Hatchery would not occur under the No-hatchery Alternative because the weirs would not be operated to collect broodstock and to remove hatchery adults.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery coho salmon are expected to have a negligible effect on natural-origin juveniles under the No-action Alternative and even these effects would not occur under the No-hatchery Alternative.

The potential impacts from these ecological interactions would occur under the No-action Alternative where hatchery smolts interact with natural-origin juveniles during the downstream migration, and if hatchery juveniles residualize and do not emigrate. In contrast, the potential impacts from competition between hatchery juveniles, the progeny of naturally spawning hatchery fish, and natural-origin juveniles in the action area would not be expected to occur under the No-hatchery Alternative because hatchery juveniles would no longer be released into the Sandy River Basin, and juvenile fish from outside the action area would not be expected to move into the Sandy River Basin.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, this factor is not a threat. Under the No-hatchery Alternative, any potential density-dependent effects in the migration corridor from the release of hatchery fish in the Sandy River would not be expected to occur because juvenile hatchery fish would not be released in the Sandy River Basin.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

Under the No-hatchery Alternative, ME&R activities that would evaluate the hatchery programs would not be expected to continue (e.g., hatchery juvenile presence and absence in lower mainstem Sandy River). However, monitoring and evaluation activities (e.g., spawning ground surveys) in the Sandy River Basin to monitor the status and recovery of the listed populations in the basin (Subsection 2.1.2, Sandy River Coho Salmon Program) and as part of the Bull Run Water Supply HCP (e.g., juvenile abundance monitoring) would be expected to continue (Subsection 1.6, Relationship to Other Plans and Policies) (NMFS 2008b).

These monitoring and evaluations activities would continue to impact listed species under the No-action Alternative due to the handling of listed adults and juveniles and from the operation of a screw trap in Cedar Creek to monitor the recolonization of habitat above the Sandy Hatchery and from other monitoring and evaluation activities that would occur annually. All of these activities would be consistent with the general guidelines developed by NMFS to reduce impacts when collecting adults and juveniles, but impacts would be expected to occur under all alternatives

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the coho salmon hatchery program would continue to have a negligible effect on ESA-listed species under the No-action Alternative. However, under the No-hatchery Alternative, no new construction at the Sandy Hatchery would occur and thus, no effects would be expected. As described in

Subsection 4.3, Effects on Water Quality and Water Quantity, if the hatchery programs are terminated, maintenance would no longer be needed and the intake structures and adult weir would not be operated, as a result water withdrawal would not occur under the No-hatchery Alternative, and passage would be provided at the adult weir and intake structure.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The release of hatchery fish to support these fisheries would not occur under the No-hatchery Alternative thus, eliminating those fisheries that would target these fish in the Sandy River Basin. The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsection 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

4.3.2.3. Sandy River Winter Steelhead

The lack of hatchery programs under the No-hatchery Alternative would be expected to have a beneficial effect on the natural-origin populations in the Sandy River because any impacts of the hatchery programs currently operating in the basin would be eliminated. Subsection 3.3.3, Sandy River Winter Steelhead, describes populations that are part of the LCR Steelhead DPS including the Sandy River winter steelhead populations. All of the other steelhead populations and their associated habitat reside outside the action area and would not be affected under the No-hatchery Alternative.

Life History

The life history characteristics of the winter steelhead population in the Sandy River would not be expected to change under the No-action Alternative. As describe in Subsection 3.3.3, Sandy River Winter Steelhead, summer steelhead are not native to the Sandy River Basin, but impacts from the release of hatchery summer steelhead can have effects on the Sandy River winter steelhead population. The winter steelhead and summer steelhead hatchery programs may impact the life history characteristics of the natural-origin winter steelhead population, but these impacts are expected to be minimal because the hatchery winter steelhead were derived from the natural-origin Sandy River winter steelhead population, and the program has incorporated natural-origin winter steelhead into the broodstock to maintain similarities between the hatchery and natural-origin winter steelhead. However, over the long term, the winter steelhead program under the No-action Alternative may impact the life history characteristics of the natural-origin winter steelhead population because natural-origin winter steelhead are no longer used for broodstock and as a result of the hatchery winter steelhead continuing to interbreed with the natural population. Under the No-hatchery Alternative this effect would not occur because the hatchery program would be terminated.

Status and Trends

The status and biological risk categories identified in Ford (2011) concluded that the LCR Steelhead DPS is at very high risk of extinction, and the Sandy River winter steelhead population was considered to also be at high to moderate risk of extinction. Under the No-action Alternative, the hatchery programs would not be expected to change the listing status and risk categories for the natural-origin winter steelhead population by the next status review, but changes to the hatchery programs that have been implemented under the No-action Alternative are expected to further reduce impacts on the natural-origin winter steelhead population. These hatchery changes along with changes to factors affecting VSP parameters have occurred since these determinations and these changes may improve the overall status of the population over the long term. However, the hatchery program would continue to pose risks under the No-action Alternative to naturally spawning hatchery fish but these risks are relatively minor, as described above. To the extent that adverse impacts on the Sandy River winter steelhead population are reduced under the No-action Alternative and the No-hatchery Alternative, it would be expected that the productivity of the natural-origin population would increase leading to more adults returning to the Sandy River Basin compared to current levels (Table 5). The effect of these hatchery changes under the No-action Alternative would continue under the No-hatchery Alternative until all of the hatchery steelhead released in the recent past had returned to the Sandy River, after which these effects would not occur. If the hatchery ceased operation prior to the return of all of the hatchery steelhead released in the recent past, then, in the short term, those returning hatchery adults would be expected to migrate past the Sandy Hatchery into upper Cedar Creek where they would adversely affect the natural-origin spawners due to their overwhelming numbers.

The recovery goal for the Sandy River winter steelhead population would not change under the No-hatchery Alternative (Subsection 1.6, Relationship to Other Plans and Policies)(ODFW 2010a; NMFS 2013c). The natural-origin Sandy River winter steelhead population would continue to be identified as a core population with a recovery target of very high probability of persistence (less than 1 percent chance of extinction or a persistence score of 4)(Table 4). Summer steelhead are not indigenous and thus, there is not a recovery goal for these fish. Under the No-hatchery Alternative, the recovery recommendations specific to the Sandy winter steelhead hatchery program would not need to be implemented, as with the general recommendations for hatchery programs, because the hatchery programs would be terminated (ODFW 2010a; NMFS 2013c).

The operation of the hatchery programs under the No-action Alternative would not be expected to have any impact on spawning habitat for winter steelhead in the action area including those areas designated as critical habitat (Table 1). The specific PCEs in the action area – freshwater spawning, freshwater rearing, and freshwater migration – would not be adversely impacted by the hatchery programs, though the operation of the weir at the Sandy Hatchery would briefly delay upstream migration for natural-origin winter steelhead returning to Cedar Creek. This impact would not occur under the No-hatchery Alternative because the hatchery weir would not be operated to collect broodstock and remove hatchery adults.

Limiting Factors and Threats

As under the No-action Alternative, the No-hatchery Alternative would not add or detract from the effect the changes that have occurred since 2004 to the impacts from resource development and municipal water supply and hydropower development and thus, their effects would continue as described in Subsection 3.3.3, Sandy River Winter Steelhead. However, impacts from the hatchery steelhead programs on the Sandy River winter steelhead population would not be expected to occur because the hatchery program would be terminated.

Effects of Hatchery Programs

The seven factors that would be used to evaluate the effects of hatchery programs on the natural-origin populations identified in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, are reviewed below under the No-hatchery Alternative with comparisons to the No-action Alternative.

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

Under the No-action Alternative and the No-hatchery Alternative, natural-origin winter steelhead would not be used for broodstock and thus there would be no effect on the natural-origin winter steelhead population.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential impacts from genetic effects are described under Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. The elimination of the winter steelhead and summer steelhead programs under the No-action Alternative would eventually reduce the number of hatchery adults that could potentially interbreed with natural-origin adults, reducing or eliminating genetic impacts (e.g., outbreeding effects, hatchery-influenced selection) on the natural winter steelhead population in the Sandy River. If the steelhead hatchery programs are eliminated, as would occur under the No-hatchery Alternative, hatchery adults that remain in the marine environment would be expected to return over the following 2 to 3 years, contributing to the number of hatchery adults that could potentially interbreed with the natural-origin winter steelhead population in the Sandy River. Straying of hatchery adults from other programs could occur because the tributary weirs and the hatchery weir would not be in operation to remove hatchery steelhead. However, the straying of out-of-basin steelhead would be expected to be at levels well below the 10 percent goal established in the recovery plans (ODFW 2010a; NMFS 2013c).

Potential impacts from the operation of weirs would not occur under the No-hatchery Alternative. Mortality from trapping and handling natural-origin winter steelhead at the Sandy Hatchery would not occur under the No-hatchery Alternative because the weir would not be operated to collect broodstock and to remove hatchery adults. However, not operating the weir at the Sandy Hatchery, would allow returning hatchery steelhead to migrate past the hatchery into

upper Cedar Creek where they would adversely affect the natural-origin spawners due to their overwhelming numbers.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery steelhead are expected to have a negligible effect on natural-origin juveniles under the No-action Alternative.

The potential impacts from these ecological interactions under the No-action Alternative would occur where hatchery smolts interact with natural-origin juveniles during the downstream migration, and if hatchery juveniles residualize and do not emigrate. The potential impacts from competition between hatchery juveniles, the progeny of naturally spawning hatchery fish, and natural-origin juveniles in the action area would not be expected to occur under the No-hatchery Alternative because hatchery juveniles would no longer be released into the Sandy River Basin, and juvenile fish from outside the action area would not be expected to move into the Sandy River Basin.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, this factor is not a threat. Under the No-hatchery Alternative, any potential density-dependent effects in the migration corridor from the release of hatchery fish in the Sandy River would not be expected to occur because juvenile hatchery fish would not be released in the Sandy River Basin.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

Under the No-hatchery Alternative, ME&R activities that would evaluate the hatchery programs would not be expected to continue (e.g., hatchery juvenile presence and absence in lower mainstem Sandy River). However, monitoring and evaluation activities (e.g., spawning ground surveys) in the Sandy River Basin to monitor the status and recovery of the listed populations in the basin (Subsection 2.1.2, Sandy River Coho Salmon Program) and as part of the Bull Run Water Supply HCP (e.g., juvenile abundance monitoring) would be expected to continue (Subsection 1.6, Relationship to Other Plans and Policies) (NMFS 2008b).

These monitoring and evaluations activities would continue to impact listed species under the No-hatchery Alternative due to the handling of listed adults and juveniles and from the operation of a screw trap in Cedar Creek to monitor the recolonization of habitat above the Sandy Hatchery and other monitoring and evaluation activities that would occur annually. All of these activities

would be consistent with the general guidelines developed by NMFS to reduce impacts when collecting adults and juveniles, but impacts would be expected to occur under all action alternatives.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the winter steelhead salmon hatchery program would continue to have a negligible effect on ESA-listed species under the No-action Alternative. However, under the No-hatchery Alternative, no new construction at the Sandy Hatchery would occur and thus, no effects would be expected. As described in Subsection 4.2, Effects on Water Quality and Water Quantity, if the hatchery programs are terminated, then the intake structures and adult weir would not be operated and the water withdrawal that occurs under the No-action Alternative would not occur under the No-hatchery Alternative.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The release of hatchery fish to support these fisheries would not occur under the No-hatchery Alternative thus, eliminating those fisheries that would target these fish in the Sandy River Basin. The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsection 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

4.3.2.4. Columbia River Chum Salmon

Life History

The presence of hatchery programs under the No-action Alternative would be expected to have no effect on Sandy River chum salmon because chum salmon are not currently present in the Sandy River. In the future, if chum salmon are reintroduced or recolonize habitat in the Sandy River, the hatchery programs under the No-action Alternative would be expected to impact chum salmon. Under the No-hatchery Alternative these impacts would not occur because the hatchery programs would be terminated. As described in Subsection 3.3.4, Columbia River Chum Salmon, the survival and growth in juvenile chum salmon depends less on freshwater conditions than on favorable estuarine and ocean conditions. These factors are outside the action area and would not be affected by the hatchery programs.

Status and Trends

Sandy River chum salmon are extirpated and no actions have been identified to actively reintroduce chum salmon into the basin.

Limiting Factors and Threats

Within the Sandy River, ODFW (2010a) identified the secondary limiting factors as including impaired upstream passage, altered hydrology, and excessive fine sediment limiting the viability of the natural population. Barriers at road crossings, including culverts on Beaver and Buck Creeks in the lower Sandy River watershed, could impede chum salmon passage in several lower Sandy River tributaries. The hatchery programs under the No-action Alternative would have no effect on these limiting factors and similarly, neither would the No-hatchery Alternative. Critical habitat designated for the Columbia River Chum Salmon ESU did not include the Sandy River Basin (Table 1), therefore, no adverse effects on critical habitat would occur under the No-hatchery Alternative as under the No-action Alternative.

The recovery goal for the Sandy River population of chum salmon, as described in the Recovery Plan ODFW (2010a), is for the population to be at low risk of extinction (less than 5 percent probability) and would not change under the No-action Alternative or the No-hatchery Alternative. An annual abundance goal was not established for this population.

If chum salmon were present in the Sandy River, impacts may occur as a result of the No-action Alternative from interactions with juvenile hatchery fish. The effect of these impacts on the ESA-listed chum salmon is expected to be negligible because ODFW would implement BMPs for hatchery practices so that hatchery fish move quickly out of the Sandy River Basin. These BMPs would not need to be implemented under the No-hatchery Alternative because the hatchery programs would be terminated. In addition, ODFW would verify with monitoring the presence of hatchery juveniles in the lower Sandy River as part of the juvenile outmigration monitoring under the No-action Alternative, which would not occur under the No-hatchery Alternative.

4.3.2.5. Pacific Eulachon

Life History

The termination of the hatchery programs would not be expected to have any effect on Pacific Eulachon. There are no data to show that the hatchery programs under the No-action Alternative would impact Pacific Eulachon life history; consequently, termination of those programs would have no effect on Pacific Eulachon.

Under the No-action Alternative and the No-hatchery Alternative, habitat in the action area designated as critical for Pacific Eulachon would not likely be affected because it is limited to the lower Sandy River below the mouth of Gordon Creek (RM 12.8). Gordon Creek enters the Sandy River at Oxbow Park (Figure 1), all of the facilities associated with the hatchery programs under the No-action Alternative are located in the Sandy River well above the mouth of Gordon Creek, and effects of the operation of those facilities are not expected to extend as far downstream as Gordon Creek.

Status and Trends

Eulachon abundance is at or near historically low levels throughout their range, including the Sandy River (Subsection 3.3.5, Pacific Eulachon). Under the No-action Alternative, the hatchery programs would not be expected to affect these abundance levels because predation of juvenile eulachon, by natural or hatchery salmon and steelhead juveniles, was not identified as a factor that was limiting the abundance or distribution of eulachon. If there were impacts from the hatchery programs, these would not occur under the No-hatchery Alternative because the hatchery programs would be terminated.

Limiting Factors and Threats

Because of the overlap in the lower Sandy River Basin between the emergence of juvenile eulachon in January through March and the release of hatchery juveniles from March through May, there would be a potential for predation on and competition with eulachon by hatchery salmonids juveniles under the No-action Alternative. In contrast, these potential adverse impacts would not occur under the No-hatchery Alternative because hatchery juveniles would not be released.

4.3.2.6. Bull Trout

As under the No-action Alternative, the No-hatchery Alternative would have no effect on bull trout in the Sandy River Basin, because few bull trout have been observed in the Sandy River Bain and these were believed to transitory migrants foraging during the winter months (USFWS 2014). In contrast to the No-action Alternative, under the No-hatchery Alternative, the potential benefit from bull trout feeding on hatchery carcasses would not occur, but this minor benefit could be replaced by an increase in the abundance of natural-origin salmon and steelhead adult carcasses.

4.3.3. Alternative 3 (Reduced Production) – Production Limited to Levels that would Achieve less-than-5 Percent pHOS Goal

Under the Reduced Production Alternative, the releases of hatchery spring Chinook salmon, coho salmon, and winter steelhead would be reduced relative to the No-action Alternative with goal of annually achieving a pHOS for the natural-origin populations of less than 5 percent (Table 2). The hatchery programs under the Reduced Production Alternative would be operated as described under the No-action Alternative, including using only hatchery returns for broodstock, acclimating and releasing the hatchery smolts either at the Sandy Hatchery (coho salmon, winter steelhead, and summer steelhead) and at the Bull Run acclimation pond (spring Chinook salmon), and operating the tributary weirs to collect broodstock and remove hatchery adults (Subsection 2.3, Alternative 3 (Reduced Production Alternative) – Production Limited to Levels that would Achieve Less-than-5 Percent pHOS goal.).

4.3.3.1. Sandy River Spring Chinook Salmon

Subsection 3.3.1, Sandy River Spring Chinook Salmon, describes populations that are part of the LCR Chinook Salmon ESU, including the three distinct Chinook salmon populations in the

Sandy River (spring, late-fall brights, and early-fall tule). None of the Chinook salmon populations outside the action area, nor their associated habitat, would be affected under the Reduced Production Alternative.

Life History

The life history characteristics of the three Chinook salmon populations in the Sandy River would not be expected to change under the Reduced Production Alternative compared to the No-action Alternative. For the tule fall Chinook salmon and late-fall Chinook salmon populations, the life histories would not be expected to change because there would be minimal, if any, effect on these run-types from the current hatchery programs (Subsection 3.3.1, Sandy River Spring Chinook Salmon). Under the No-action Alternative, the spring Chinook salmon hatchery program may impact the life history characteristics of the natural-origin spring Chinook salmon population, but these impacts are expected to be minimal because the hatchery spring Chinook salmon were derived from the natural-origin Sandy River spring Chinook salmon population, and the program has incorporated natural-origin spring Chinook salmon into the broodstock to maintain similarities between the hatchery and natural-origin spring Chinook salmon. However, over the long term, the spring Chinook salmon program under the No-action Alternative may impact the life history characteristics of the natural-origin spring Chinook salmon population because natural-origin spring Chinook salmon are no longer used for broodstock and as a result of the hatchery spring Chinook salmon continuing to interbreed with the natural population. The impact of hatchery spring Chinook salmon interbreeding with the natural population would be expected to decrease under the Reduced Production Alternative because fewer hatchery fish would be released compared to the No-action Alternative, thereby reducing the potential number of hatchery adults that would spawn naturally.

The impacts on the natural spring Chinook salmon population under the Reduced Production Alternative would be greater than under the No-hatchery Alternative because hatchery fish would still be released.

Status and Trends

The ESA-listing status and risk categories for the three natural-origin Chinook salmon populations in the Sandy River Basin are not expected to change under the Reduced Production Alternative compared to the No-action Alternative. Impacts from the hatchery programs would not be expected to change risk categories for the tule fall Chinook salmon population or the late fall Chinook salmon population because impacts from the hatchery programs would be minor, and the majority of the limiting factors for these populations would not be affected by the proposed hatchery programs. The listing status and risk categories for the natural-origin spring Chinook salmon population would not be expected to change by next status review, but changes to the hatchery programs that would be implemented under the Reduced Production Alternative are expected to further reduce impacts on the natural-origin spring Chinook salmon population. These impacts under the Reduced Production Alternative, though minor, would be intermediate between the No-action Alternative and the No-hatchery Alternative.

The recovery goal for the Sandy River spring Chinook salmon population would not change under the Reduced Production Alternative (Subsection 1.6, Relationship to Other Plans and Policies) (ODFW 2010a; NMFS 2013c). The natural-origin Sandy River spring Chinook salmon population would continue to be identified as a core and genetic legacy population with a recovery target of high probability of persistence (score of 3). Under the Reduce Production Alternative, as under the No-action Alternative, the recovery recommendations specific to the Sandy spring Chinook salmon program would be implemented, as would the general recommendations for hatchery programs.

The operation of the hatchery programs under the Reduced Production Alternative, as under the No-action Alternative, would not be expected to have any impact on the anchor habitat or spawning areas for Sandy River spring Chinook salmon though the operation of the weirs in the Zigzag River and Salmon River impact their use by the natural-origin spring Chinook salmon population. Under these alternatives, the essential physical and biological features affecting freshwater spawning, freshwater rearing, and freshwater migration that were designated as critical habitat for the LCR Chinook Salmon ESU in the action area would continue to be affected by hatchery operations, weirs, or intake structures (Subsection 3.3.1, Sandy River Spring Chinook Salmon). However, the impacts from the operation of the hatchery program on critical habitat are not expected to occur because the hatchery program would not directly impact habitat. As under the No-action Alternative, the weirs would be expected to have a minor impact on the habitat because they are temporary, disturb a limited area, and are operated to minimize delay in migration.

Limiting Factors and Threats

As under the No-action Alternative and the No-hatchery Alternative, the Reduced Production Alternative would not add or detract from the effect the changes that have occurred since 2004 to the impacts from resource development and municipal water supply and hydropower development and thus, their effects would continue as described in Subsection 3.3.1, Sandy River Spring Chinook Salmon. However, the effects of the spring Chinook salmon program on the Sandy River spring Chinook salmon population would be expected to be reduced relative to the No-action Alternative because fewer hatchery adults would be produced. These impacts would be greater than what would occur under the No-hatchery Alternative.

Effects of Hatchery Programs

The seven factors used to evaluate the effects of hatchery programs on the natural-origin populations identified in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, are reviewed below under the Reduced Production Alternative with comparisons to the No-action Alternative.

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

Under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative, natural-origin spring Chinook salmon would not be used for broodstock and thus, there would be no effect on the natural-origin spring Chinook salmon population.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential impacts of genetic effects are described under Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. Effects under the No-action Alternative are described in Subsection 4.3.1.1, Sandy River Spring Chinook Salmon. Genetic effects of hatchery-influenced selection under the Reduced Production Alternative would be expected to be less than those under the No-action Alternative because the program would be operated such that the pHOS goal would be less than 5 percent, compared to the pHOS goal of less than 10 percent under the No-action Alternative. The reduction in effects between the 10 percent pHOS goal and 5 percent pHOS goal would be expected to be minor, even though the 5 percent goal would meet the HSRG (2014) recommended pHOS for segregated programs. The HSRG (2014) identified that segregated programs may require a pHOS goal that is lower than 5 percent because, even at this level, reducing the risks from hatchery-influenced selection may be insufficient to safeguard the viability of the natural-origin population. Under the Reduced Production Alternative the effects on the natural-origin population from hatchery-influenced selection would be even less than the 5 percent pHOS goal would indicate.

As described under the evaluation of the No-action Alternative, the HSRG makes no distinction between hatchery programs using broodstock from outside the ESU/DPS and those programs that were derived from the local natural-origin population, only indicating that the impacts would be greater given the more divergence between the hatchery and natural-origin populations. This is in contrast to the ICTRT (2007a) which showed decreasing risk to the natural population depending on the source of the hatchery spawners and how the hatchery programs was operated (Figure 13). In Figure 13, the bottom graph would represent a hatchery program that was integrated, and the graph immediately above it would represent a hatchery program that was segregated but was derived from the natural-origin population (ICTRT 2007a). For this latter group, a pHOS of 5 percent would pose a low risk to the viability of the natural population over a longer period than a pHOS of 10 percent but would be a moderate risk over the long term.

Furthermore, the less-than-5 percent pHOS goal that the HSRG recommends is the value that its modeling shows would limit the influence of the segregated hatchery program on the viability of the natural-origin population after many generations. The HSRG model also assumes that spawning between hatchery and natural-origin adults is completely random, where the chances of all three types of crosses (HxH, HxN, and NxN) are equally likely to occur. If this assumption was correct, then based on the analysis of the mating-frequency in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, and in Figure 14, a pHOS level of 5 percent (0.05) should result in approximately 90 percent of the matings being NxN, 9 percent being NxH, and less than 1 percent being HxH. This would ensure that 9 out of 10 matings would be NxN, which would limit impacts on the natural-origin population from hatchery-influenced selection. The actual level of HxN would probably be substantially less under the Reduced Production Alternative because there would be fewer returning hatchery adults and the hatchery adults tend to be distributed lower in the Sandy River Basin away from the natural spawning areas.

Impacts from hatchery-influenced selection would occur under the Reduced Production Alternative, and would be expected to be less than those observed under the No-action Alternative, but would be expected to be greater than under the No-hatchery Alternative because, under that alternative, hatchery spring Chinook salmon would not be released.

Under the Reduced Production Alternative, the weirs would continue to be operated in the Zigzag, Salmon, and Bull Run Rivers; therefore, their impacts would be the same as those described under the No-action Alternative. These impacts would not occur under the No-hatchery Alternative. The potential effects of weir rejection resulting in changes in spawning distribution, migration delay affecting spawn timing, and delayed mortality from handling at the weirs may be reduced under the Reduced Production Alternative. If monitoring shows that the proportion of hatchery spring Chinook salmon removed at the Zigzag River and Salmon River weirs are at such low levels that if they were not trapped and removed, the estimated pHOS would be below the 5 percent goal, then the two upper basin weirs would not need to be operated, thus reducing impacts associated with the weirs. Impacts from the operation of the Bull Run weir would continue to occur under this scenario, and the impacts would be the same as for the No-action Alternative. Adverse impacts associated with weirs would not occur under the No-hatchery Alternative because the weirs would not be operated to collect broodstock and to remove hatchery adults.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery spring Chinook salmon are expected to have a negligible effect on natural-origin juveniles under the No-action Alternative, and would have an even lower effect under the Reduced Production Alternative because few hatchery juveniles would be released.

These potential impacts from ecological interactions would occur where hatchery smolts interact with natural-origin juveniles during the downstream migration, and if hatchery juveniles residualize and do not emigrate. The potential impacts from competition between hatchery juveniles, the progeny of naturally spawning hatchery fish, and natural-origin juveniles in the action area would be expected to be less than what would occur under the No-action Alternative because there would be fewer hatchery juveniles released under the Reduced Production Alternative. These competition-related adverse impacts would not occur under the No-hatchery Alternative because hatchery fish would no longer be released into the Sandy River Basin, and juvenile fish from outside the action area would not be expected to move into the Sandy River Basin.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on

ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, this factor is not a threat. Under the Reduced Production Alternative, any potential impact would be less than that under the No-action Alternative because there would be fewer juveniles released. Under the No-hatchery Alternative, any potential density-dependent effects in the migration corridor from the release of hatchery fish in the Sandy River would not be expected to occur because juvenile hatchery fish would no longer be released in the Sandy River Basin.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

As under the No-action Alternative, ME&R activities to evaluate the hatchery program would be expected to continue (e.g., hatchery juvenile presence and absence in lower mainstem Sandy River) under the Reduced Production Alternative. Additionally, monitoring and evaluation activities (e.g., spawning ground surveys) in the Sandy River Basin to monitor the status and recovery of the listed populations in the basin (Subsection 2.1.1, Sandy River Spring Chinook Salmon Program) and as part of the Bull Run Water Supply HCP would also continue (Subsection 1.6, Relationship to Other Plans and Policies) (NMFS 2008b).

These monitoring and evaluations activities would continue to impact listed species due to the handling of listed adults and juveniles and from the operation of a screw trap in Cedar Creek to monitor the recolonization of habitat above the Sandy Hatchery. All of these activities would be consistent with the general guidelines developed by NMFS to reduce impacts when collecting adults and juveniles, but impacts would be expected to occur under all of the action alternatives.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the hatchery programs would continue to have a negligible effect on ESA-listed species under the Reduced Production Alternative. Under the Reduced Production Alternative, no new construction at the Sandy Hatchery would occur and, thus, no effects would be expected. Water intake structures and water withdrawal present another set of potential effects on listed salmonids, and these were evaluated in Subsection 4.2, Effects on Water Quality and Water Quantity.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The release of hatchery fish to support these fisheries would occur under the Reduced Production Alternative, but fewer hatchery adults would be expected to be available compared to the No-action Alternative because few hatchery juveniles would be released. The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsection 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

4.3.3.2. Sandy River Coho Salmon

Subsection 3.3.2, Sandy River Coho Salmon, describes populations that are part of the LCR Coho salmon ESU including the Sandy River coho salmon population. All of the other coho salmon populations and their associated habitat reside outside the action area and would not be affected under the Reduced Production Alternative.

Life History

Under the Reduced Production Alternative, impacts on the life history of the coho salmon population in the Sandy River would not be expected to occur. The hatchery coho salmon program could impact the life history characteristics of the natural-origin coho salmon population, but these impacts are expected to be minimal over the near term because NMFS (2003a) determined that the Sandy River hatchery coho salmon program was no more than moderately diverged from the natural population in the watershed, and that the stock was derived from the local, natural-origin population. It was not considered to be minimally divergent because the hatchery program did not incorporate substantial numbers of natural-origin fish into the broodstock. Based on this determination, NMFS considers the hatchery program to be integrated with the natural population. However, over the long term, the coho salmon program under the No-action Alternative may impact the life history characteristics of the natural-origin coho salmon population because natural-origin coho salmon are not used for broodstock and as a result of the hatchery coho salmon continuing to interbreed with the natural population. The impact of hatchery coho salmon interbreeding with the natural population would be expected to decrease under the Reduced Production Alternative because fewer hatchery fish would be released reducing the potential number of hatchery adults that spawn naturally.

The impacts on the natural coho salmon population under the Reduced Production Alternative would be greater than under the No-hatchery Alternative and less than the No-action Alternative because hatchery releases would be at levels intermediate to the other alternatives.

Status and Trends

The status and biological risk categories identified in Ford (2011) concluded that the LCR Coho Salmon ESU is at very high risk of extinction; however, the Sandy River coho salmon population was considered to be at high to moderate risk of extinction. ODFW (2010a) determined that the Sandy River coho salmon population abundance and productivity parameter had decreased relative to that observed by McElhany et al. (2007), and this contributed to the lowering of the overall status to high risk (Figure 8). The listing status and risk categories for the natural-origin coho salmon population would not be expected to change by the next status review, but changes to the hatchery programs that have been implemented under the No-action Alternative are expected to further reduce impacts on the natural-origin coho salmon population. These hatchery changes along with factors affecting VSP parameters have changed since these determinations, and these changes may improve the overall status of the population over the long term. However, the hatchery program would continue to pose risks under the No-action Alternative due naturally spawning hatchery fish but these risks are minor These risks would be expected to be less under the Reduced Production Alternative because fewer hatchery adults would be returning that could potentially interbreed with natural-origin coho salmon. These risk impacts would not occur under

the No-hatchery Alternative. To the extent that adverse impacts on Sandy River coho salmon populations under the No-action Alternative and the Reduced Production Alternative are reduced, it would be expected that the productivity of the natural-origin population would increase, leading to more adults returning to the Sandy River Basin compared to current levels (Table 5).

The recovery goal for the Sandy River coho salmon population would not change under the Reduced Production Alternative (Subsection 1.6, Relationship to Other Plans and Policies) (ODFW 2010a; NMFS 2013c). The natural-origin Sandy River coho salmon population would continue to be identified as key to recovery of the Cascade coho salmon strata and the LCR coho salmon ESU with a target of high probability of persistence (score of 3). Under the Reduce Production Alternative, as with the No-action Alternative, the recovery recommendations specific to the Sandy Hatchery coho salmon program would be implemented, as would the general recommendations for hatchery programs.

The operation of the hatchery programs under the Reduced Production Alternative would not be expected to have any impact on the anchor habitat or spawning areas for Sandy River coho salmon though the operation of the tributary weirs, and the adult weir at the Sandy Hatchery may impact use of such areas by the natural-origin coho salmon population. These adverse weir effects would not occur under the No-hatchery Alternative.

Limiting Factors and Threats

As under the No-action Alternative and the No-hatchery Alternative, the Reduced Production Alternative would not add or detract from the effect the changes that have occurred since 2004 to the impacts from resource development and municipal water supply and hydropower development and thus, their effects would continue as described in Subsection 3.3.2, Sandy River Coho Salmon. However, the effects of the coho salmon program on the Sandy River coho salmon population would be expected to be reduced relative to the No-action Alternative because fewer hatchery adults would be produced.

Effects of Hatchery Programs

The seven factors used to evaluate the effects of hatchery programs on the natural-origin populations identified in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, are reviewed below under the Reduced Production Alternative with comparisons to the No-action Alternative.

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

Under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative, natural-origin coho salmon would not be used for broodstock and, thus, none of these alternatives would have an effect on the natural-origin coho salmon population through their collection for broodstock.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential impacts from genetic effects are described under Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. Effects under the No-action Alternative are described in Subsection 4.3.1.2, Sandy River Coho Salmon. Genetic effects from hatchery-influenced selection under the Reduced Production Alternative would be expected to be less than those under the No-action Alternative because the program would be operated such that the pHOS goal would be less than 5 percent, compared to the pHOS goal of less than 10 percent under the No-action Alternative. The reduction in effects between the 5 percent pHOS goal and 10 percent pHOS goal would be expected to be minor, even though the 5 percent goal would meet the HSRG (2014) recommended pHOS for segregated programs. The HSRG (2014) identified that segregated programs may require a pHOS goal that is lower than 5 percent because, even at this level, reducing the risks from hatchery-influenced selection may be insufficient to safeguard the viability of the natural-origin population. Under the Reduced Production Alternative, the effects on the natural-origin population from hatchery-influenced selection would be even smaller than the 5 percent pHOS goal would indicate.

As described under the evaluation of the No-action Alternative, the HSRG makes no distinction between hatchery programs using broodstock from outside the ESU/DPS and those programs that were derived from the local natural-origin population, only indicating that the impacts would be greater given the more divergence between the hatchery and natural-origin populations. This is in contrast to the ICTRT (2007a) that showed decreasing risk to the natural population depending on the source of the hatchery spawners and how the hatchery programs was operated (Figure 13). In Figure 13, the bottom graph would represent a hatchery program that was integrated, and the graph immediately above it would represent a hatchery program that was segregated but was derived from the natural-origin population (ICTRT 2007a). For this latter group, a pHOS of 5 percent would pose a low risk to the viability of the natural population over a longer period than a pHOS of 10 percent but would be a moderate risk over the long term.

Furthermore, the less-than-5 percent pHOS goal that the HSRG recommends is the value that its modeling shows would limit the influence of the segregated hatchery program on the viability of the natural-origin population after many generations. The HSRG model also assumes that spawning between hatchery and natural-origin adults is completely random, where the chances of all three types of crosses (HxH, HxN, and NxN) are equally likely to occur. If this assumption was correct, then based on the analysis of the mating-frequency in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, and in Figure 14, a pHOS level of 5 percent (0.05) should result in approximately 90 percent of the matings being NxN, 9 percent being NxH, and less than 1 percent being HxH. This would ensure that 9 out of 10 matings would be NxN, which would limit impacts on the natural-origin population from hatchery-influenced selection. The actual level of HxN would probably be substantially less under the Reduced Production Alternative because there would be fewer returning hatchery adults and the hatchery adults tend to be distributed lower in the Sandy River Basin away from the natural spawning areas.

Based on the evaluation above, impacts from hatchery-influenced selection would occur under the Reduced Production Alternative, but would be expected to be less than those observed under

the No-action Alternative. These impacts from hatchery-influenced selection would not be expected to occur under the No-hatchery Alternative.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery coho salmon are expected to have a negligible effect on natural-origin juveniles under the No-action Alternative, and would have an even lower effect under the Reduced Production Alternative because few hatchery juveniles would be released.

These potential impacts from ecological interactions would occur where hatchery smolts interact with natural-origin juveniles during the downstream migration, and if hatchery juveniles residualize and do not emigrate. The potential impacts from competition between hatchery juveniles, the progeny of naturally spawning hatchery fish, and natural-origin juveniles in the action area would be expected to be less than what would occur under the No-action Alternative because there would be fewer hatchery juveniles released under the Reduced Production Alternative. Completion-related impacts would not occur under the No-hatchery Alternative because hatchery fish would no longer be released into the Sandy River Basin, and juvenile fish from outside the action area would not be expected to move into the Sandy River Basin.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, this factor is not a threat. Under the Reduced Production Alternative, any potential impact would be less than that for the No-action Alternative because there would be fewer juveniles released. Under the No-hatchery Alternative, no density-dependent effects in the migration corridor from the release of hatchery fish in the Sandy River would occur because juvenile hatchery fish would no longer be released in the Sandy River Basin.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

As under the No-action Alternative, ME&R activities to evaluate the hatchery program would be expected to continue (e.g., hatchery juvenile presence and absence in lower mainstem Sandy River) under the Reduced Production Alternative. Additionally, monitoring and evaluation activities (e.g., spawning ground surveys) in the Sandy River Basin to monitor the status and recovery of the listed populations in the basin (Subsection 2.1.1, Sandy River Spring Chinook Salmon Program) and as part of the Bull Run Water Supply HCP would also continue (Subsection 1.6, Relationship to Other Plans and Policies) (NMFS 2008b).

These monitoring and evaluations activities would continue to impact listed species due to the handling of listed adults and juveniles and from the operation of a screw trap in Cedar Creek to monitor the recolonization of habitat above the Sandy Hatchery. All of these activities would be consistent with the general guidelines developed by NMFS to reduce impacts when collecting adults and juveniles, but impacts would be expected to occur all of the action alternatives.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the hatchery programs would continue to have a negligible effect on ESA-listed species under the Reduced Production Alternative. Under the Reduced Production Alternative, no new construction at the Sandy Hatchery would occur and thus, no effects would be expected. Water intake structures and water withdrawal present another set of potential effects on listed salmonids, and these were evaluated in Subsection 4.2, Effects on Water Quality and Water Quantity.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The release of hatchery fish to support these fisheries would occur under the Reduced Production Alternative but fewer hatchery adults would be expected to be available compared to the No-action Alternative because few hatchery juveniles would be released. The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsection 3.7, Socioeconomics, and Subsection3.8, Tourism and Recreation.

4.3.3.3. Sandy River Winter Steelhead

Subsection 3.3.3, Sandy River Winter Steelhead, describes populations that are part of the LCR Steelhead DPS including the Sandy River winter steelhead population. All of the other steelhead populations and their associated habitat reside outside the action area and would not be affected under the Reduced Production Alternative.

Life History

The life history characteristics of the winter steelhead population in the Sandy River would not be expected to change under the Reduced Production Alternative or the No-action Alternative. As describe in Subsection 3.3.3, Sandy River Winter Steelhead, summer steelhead are not native to the Sandy River Basin, but impacts from the release of hatchery summer steelhead can have effects on the Sandy River winter steelhead population. The winter steelhead and summer steelhead hatchery programs may impact the life history characteristics of the natural-origin winter steelhead population, but these impacts are expected to be minimal because the hatchery winter steelhead were derived from the natural-origin Sandy River winter steelhead population, and the program has incorporated natural-origin winter steelhead into the broodstock to maintain

similarities between the hatchery and natural-origin winter steelhead. However, over the long term, the winter steelhead program under the No-action Alternative and the Reduced Production Alternative may impact the life history characteristics of the natural-origin winter steelhead population because natural-origin winter steelhead are no longer used for broodstock and as a result of the hatchery winter steelhead continuing to interbreed with the natural population. The impact of hatchery steelhead interbreeding with the natural population would be expected to decrease under the Reduced Production Alternative because fewer hatchery fish would be released reducing the potential number of hatchery adults that spawn naturally. The impacts on the natural coho salmon population under the Reduced Production Alternative would be greater that under the No-hatchery Alternative because hatchery fish would be released.

Status and Trends

The status and biological risk categories identified in Ford (2011) concluded that the LCR Steelhead DPS is at very high risk of extinction, and the Sandy River winter steelhead population was considered to also be at high to moderate risk of extinction. Under the No-action Alternative, the hatchery programs would not be expected to change the listing status and risk categories for the natural-origin winter steelhead population by the next status review, but changes to the hatchery programs that have been implemented under the No-action Alternative and would continue under the Reduced Production Alternative would be expected to further reduce impacts on the natural-origin winter steelhead population. These hatchery changes along with factors affecting VSP parameters have changed since these determinations, and these changes may improve the overall status of the population over the long term. However, the hatchery program would continue to pose risks under the No-action Alternative due to naturally spawning hatchery fish but these risks are minor. These risks would be expected to be less under the Reduced Production Alternative because fewer hatchery adults would be returning that could potentially interbreed with natural-origin coho salmon. These impacts would not occur under the No-hatchery Alternative. To the extent that adverse impacts on Sandy River coho salmon populations under the No-action Alternative and the Reduced Production Alternative are reduced, it would be expected that the productivity of the natural-origin population would increase, leading to more adults returning to the Sandy River Basin compared to current levels Table 5).

The recovery goal for the Sandy River winter steelhead population would not change under the Reduced Production Alternative (Subsection 1.6, Relationship to Other Plans and Policies)(ODFW 2010a; NMFS 2013c). The natural-origin Sandy River winter steelhead population would continue to be identified as a core population with a recovery target of very high probability of persistence (less than 1 percent chance of extinction or a persistence score of 4)(Table 4). Summer steelhead are not indigenous and thus, there is not a recovery goal for these fish. Under the No-action Alternative and the Reduced Production Alternative the recovery recommendations specific to the Sandy winter steelhead program would be implemented, as would the general recommendations for hatchery programs (ODFW 2010a; NMFS 2013c).

The operation of the hatchery programs under the No-action Alternative and the Reduced Production Alternative would not be expected to have any impact on spawning habitat for winter steelhead in the action area including those areas designated as critical habitat (Table 1). The specific PCEs in the action area – freshwater spawning, freshwater rearing, and freshwater

migration – would not be adversely impacted by the hatchery programs, though the operation of the weir at the Sandy Hatchery would briefly delay upstream migration for natural-origin winter steelhead returning to Cedar Creek.

Limiting Factors and Threats

As with the No-action Alternative and the No-hatchery Alternative, the Reduced Production Alternative would not add or detract from the effect the changes that have occurred since 2004 to the impacts from resource development and municipal water supply and hydropower development and, therefore, their effects would continue as described in Subsection 3.3.3, Sandy River Winter Steelhead. However, the effects of the steelhead programs on the Sandy River winter steelhead population would be expected to be reduced relative to the No-action Alternative because fewer hatchery adults would be produced.

Effects of Hatchery Programs

The seven factors used to evaluate the effects of hatchery programs on the natural-origin populations identified in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, are reviewed below under the Reduced Production Alternative with comparisons to the No-action Alternative.

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

Under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative, natural-origin winter steelhead would not be used for broodstock and thus there would be no effect on the natural-origin winter steelhead population as a result of collection for broodstock.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential impacts from genetic effects are described under Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. Effects under the No-action Alternative are described in Subsection 4.3.1.3, Sandy River Winter Steelhead. Genetic effects from hatchery-influenced selection under the Reduced Production Alternative would be expected to be less than those under the No-action Alternative because the program would be operated such that the pHOS goal would be less than 5 percent, compared to the pHOS goal of less than 10 percent under the No-action Alternative. The reduction in effects between the 5 percent pHOS goal and 10 percent pHOS goal would be expected to be minor, even though the 5 percent goal would meet the HSRG (2014) recommended pHOS for segregated programs. The HSRG (2014) identified that segregated programs may require a pHOS goal that is lower than 5 percent because, even at this level, reducing the risks from hatchery-influenced selection may be insufficient to safeguard the viability of the natural-origin population. Under the Reduced Production Alternative, the effects on the natural-origin population from hatchery-influenced selection would be even smaller than the 5 percent pHOS goal would indicate.

As described under the evaluation of the No-action Alternative, the HSRG makes no distinction between hatchery programs using broodstock from outside the ESU/DPS and those programs that were derived from the local natural-origin population, only indicating that the impacts would be greater given the more divergence between the hatchery and natural-origin populations. This is in contrast to the ICTRT (2007a) that showed decreasing risk to the natural population depending on the source of the hatchery spawners and how the hatchery programs was operated (Figure 13). In Figure 13, the bottom graph would represent a hatchery program that was integrated, and the graph immediately above it would represent a hatchery program that was segregated but was derived from the natural-origin population (ICTRT 2007a). For this latter group, a pHOS of 5 percent would pose a low risk to the viability of the natural population over a longer period than a pHOS of 10 percent but would be a moderate risk over the long term.

Furthermore, the less-than-5 percent pHOS goal that the HSRG recommends is the value that its modeling shows would limit the influence of the segregated hatchery program on the viability of the natural-origin population after many generations. The HSRG model also assumes that spawning between hatchery and natural-origin adults is completely random, where the chances of all three types of crosses (HxH, HxN, and NxN) are equally likely to occur. If this assumption was correct, then based on the analysis of the mating-frequency in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, and in Figure 14, a pHOS level of 5 percent (0.05) should result in approximately 90 percent of the matings being NxN, 9 percent being NxH, and less than 1 percent being HxH. This would ensure that 9 out of 10 matings would be NxN, which would limit impacts on the natural-origin population from hatchery-influenced selection. The actual level of HxN would probably be substantially less under the Reduced Production Alternative because there would be fewer returning hatchery adults and the hatchery adults tend to be distributed lower in the Sandy River Basin away from the natural spawning areas and the temporal separation between the summer steelhead and natural-origin winter steelhead. Impacts from hatchery-influenced selection would occur under the Reduced Production Alternative, and would be expected to be less than those observed under the No-action Alternative; these impacts would not be expected to occur under the No-hatchery Alternative.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery winter and summer steelhead are expected to have a negligible effect on natural-origin juveniles under the No-action Alternative, and would have an even smaller effect under the Reduced Production Alternative because fewer juveniles would be released.

These potential impacts from ecological interactions would occur where hatchery smolts interact with natural-origin juveniles during the downstream migration, and would be somewhat higher if hatchery juveniles residualize and do not emigrate. The potential impacts from competition between hatchery juveniles, the progeny of naturally spawning hatchery fish, and natural-origin juveniles in the action area would be expected to be less than what would occur under the No-action Alternative because the number of juveniles outmigrating would be reduced compared to

the number of steelhead released under the No-action Alternative. These impacts would not occur under the No-hatchery Alternative because hatchery fish would no longer be released into the Sandy River Basin, and juvenile fish from outside the action area would not be expected to move into the Sandy River Basin.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, this factor is not a threat. Under the Reduced Production Alternative, any potential impact would be less than that for the No-action Alternative because there would be fewer juveniles released. Under the No-hatchery Alternative, any potential density-dependent effects in the migration corridor from the release of hatchery fish in the Sandy River would not be expected to occur because juvenile hatchery fish would no longer be released in the Sandy River Basin.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

As under the No-action Alternative, ME&R activities to evaluate the hatchery program would be expected to continue (e.g., hatchery juvenile presence and absence in lower mainstem Sandy River) under the Reduced Production Alternative. Additionally, monitoring and evaluation activities (e.g., spawning ground surveys) in the Sandy River Basin to monitor the status and recovery of the listed populations in the basin (Subsection 2.1.1, Sandy River Spring Chinook Salmon Program) and as part of the Bull Run Water Supply HCP would also continue (Subsection 1.6, Relationship to Other Plans and Policies) (NMFS 2008b).

These monitoring and evaluations activities would continue to impact listed species due to the handling of listed adults and juveniles and from the operation of a screw trap in Cedar Creek to monitor the recolonization of habitat above the Sandy Hatchery. All of these activities would be consistent with the general guidelines developed by NMFS to reduce impacts when collecting adults and juveniles, but impacts would be expected to occur under all of the action alternatives.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the hatchery programs would continue to have a negligible effect on ESA-listed species under the Reduced Production Alternative. Under the Reduced Production Alternative, no new construction at the Sandy Hatchery would occur and thus, no effects would be expected. Water intake structures and water withdrawal present another set of potential effects on listed salmonids, and these were evaluated in Subsection 4.2, Effects on Water Quality and Water Quantity.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The release of hatchery fish to support these fisheries would occur under the Reduced Production Alternative but fewer hatchery adults would be expected to be available compared to the No-action Alternative because few hatchery juveniles would be released. The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsections 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

4.3.3.4. Columbia River Chum Salmon

Life History

The presence of hatchery programs under the Reduced Production Alternative would be expected to have no effect on Sandy River chum salmon, and its life history, because chum salmon are not currently present in the Sandy River. In the future, if chum salmon are reintroduced or recolonize habitat in the Sandy River, the hatchery programs under the No-action Alternative would be expected to impact chum salmon. Under the Reduced Production Alternative, these impacts would be expected to be less because fewer hatchery juveniles would be released. Under the No-hatchery Alternative these impacts would not occur because the hatchery programs would be terminated. As described in Subsection 3.3.4, Columbia River Chum Salmon, the survival and growth in juvenile chum salmon depends less on freshwater conditions than on favorable estuarine and ocean conditions. These factors are outside the action area and would not be affected by the hatchery programs.

Status and Trends

Sandy River chum salmon are extirpated and no actions have been identified to actively reintroduce chum salmon into the basin.

Limiting Factors and Threats

Within the Sandy River, ODFW (2010a) identified the secondary limiting factors as including impaired upstream passage, altered hydrology, and excessive fine sediment limiting the viability of the natural population. Barriers at road crossings, including culverts on Beaver and Buck Creeks in the lower Sandy River watershed, could impede chum salmon passage in several lower Sandy River tributaries. The hatchery programs under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative would not have an effect on these limiting factors. Critical habitat designated for the Columbia River Chum Salmon ESU did not include the Sandy River Basin (Table 1).

The recovery goal for the Sandy River population of chum salmon, as described in the Recovery Plan (ODFW 2010a), is for the population to be at low risk of extinction (less than 5 percent

probability) and would not change under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative. An annual abundance goal was not established for this population. There are no specific hatchery actions to address impacts of the Sandy River Hatchery programs on chum salmon, other than improving passage at the hatchery intake and adult weir on Cedar Creek, which has been completed.

If chum salmon were present in the Sandy River, impacts may occur as a result of the Reduced Production Alternative and the No-action Alternative from interactions with juvenile hatchery fish. The effect of these impacts on the ESA-listed chum salmon is expected to be negligible under either alternative because ODFW would implement the following BMPs so that hatchery fish move quickly out of the Sandy River Basin. These BMPs include rearing juveniles to the sizes and under conditions identified in the HGMPs, i.e., continuing to mark all hatchery juveniles, and acclimating hatchery juveniles prior to release. In addition, ODFW would verify with monitoring the presence of hatchery juveniles in the lower Sandy River as part of the juvenile outmigration monitoring; results would be reported annually.

4.3.3.5. Pacific Eulachon

Life History

The presence of hatchery programs under the Reduced Production Alternative would be expected to have an impact on eulachon in the Sandy River. This impact would likely be smaller than under the No-action Alternative because fewer hatchery juveniles would be released, and would not be expected to affect the life history characteristics of Pacific Eulachon. These impacts would not be expected to occur under the No-hatchery Alternative because the hatchery programs would be terminated.

Under the action alternatives, designated critical habitat in the action area would not likely be affected because it is limited to the lower Sandy River below the mouth of Gordon Creek (RM 12.8). Gordon Creek enters the Sandy River at Oxbow Park (Figure 1) and all of the facilities associated with the hatchery programs under the No-action Alternative and the Reduced Production Alternative are located in the Sandy River well above the mouth of Gordon Creek and thus would not be expected to impact Pacific eulachon habitat.

Status and Trends

Eulachon abundance is at or near, historically low levels throughout their range, including the Sandy River (Subsection 3.3.5, Pacific Eulachon). Under the Reduced Production Alternative, as with the No-action Alternative, the hatchery programs would not be expected to have an impact on abundance levels because predation of juvenile eulachon, by either natural or hatchery juvenile salmon and steelhead, was not identified as a factor that was limiting the abundance or distribution of eulachon.

Limiting Factors and Threats

Because of the overlap in the lower Sandy River Basin between the emergence of juvenile eulachon in January through March and the release of hatchery juveniles from March through

May, there would be a potential for predation on and competition with eulachon by hatchery salmonids juveniles under the No-action Alternative. This potential for predation and competition would be less under the Reduced Production Alternative because fewer juveniles would be released. In contrast, these potential adverse impacts would not occur under the No-hatchery Alternative.

4.3.3.6. Bull Trout

The Reduced Production Alternative would have no effect on bull trout in the Sandy River Basin, because few bull trout have been observed in the Sandy River Bain, and these were believed to transitory migrants foraging during the winter months (USFWS 2014). Under the Reduced Production Alternative, the potential benefit to bull trout from the availability of hatchery carcasses as a food source would be reduced in comparison to the No-action Alternative because the hatchery production would be lower than under the No-action Alternative. This reduction could be replaced by an increase in the abundance of natural-origin salmon and steelhead adult carcasses.

4.3.4. Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule

Under the Proposed Action Alternative, the releases of hatchery spring Chinook salmon, coho salmon, and winter steelhead would be similar to the No-action Alternative except that spring Chinook salmon production would initially start at 135,000 smolts, but could increase to 300,000 smolts as under the No-action Alternative if the pHOS goal of less than 10 percent can be achieved (Table 2). The coho salmon program would be reduced by 40 percent to 300,000 smolts. The hatchery programs under the Proposed Action Alternative would be operated as described under the Proposed Action Alternative, including the incorporation of natural-origin adults in the spring Chinook salmon and winter steelhead broodstocks. The acclimation and release of the hatchery smolts either at the Sandy Hatchery (coho salmon, winter steelhead, and summer steelhead) and at the Bull Run acclimation pond (spring Chinook salmon) and operation of the tributary weirs to collect broodstock and remove hatchery adults would be the same as the No-action Alternative (Subsection 2.4, Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule).

4.3.4.1. Sandy River Spring Chinook Salmon

Subsection 3.3.1, Sandy River Spring Chinook Salmon, describes populations that are part of the LCR Chinook Salmon ESU, including the three distinct Chinook salmon populations in the Sandy River (spring, late-fall brights, and early-fall tule). None of the Chinook salmon populations outside the action area, nor their associated habitat, would be affected under the Proposed Action Alternative.

Life History

The life history characteristics of the three Chinook salmon populations in the Sandy River would not be expected to change under the Proposed Action Alternative. For the tule fall Chinook salmon and late-fall Chinook salmon populations, the life-histories would not be

expected to change because there would be minimal, if any, effect on these run-types from the current hatchery programs (Subsection 3.3.1, Sandy River Spring Chinook Salmon). Under the Proposed Action Alternative, impacts of the spring Chinook salmon hatchery program on life history characteristics of the natural-origin spring Chinook salmon population are expected to be lower than under the No-action Alternative because natural-origin spring Chinook salmon would be incorporated into the hatchery broodstock such that the hatchery spring Chinook salmon would be more similar to the natural-origin population than would occur under the No-action Alternative. The impact of hatchery spring Chinook salmon interbreeding with the natural population would be expected to be less than what would be observed under the Reduced Production Alternative – even though more hatchery fish would be released under the Proposed Action than under the Reduced Production Alternative, those hatchery adults that do spawn naturally would be more representative of the natural-origin population than those produced under the Reduced Production Alternative or the No-action Alternative. The impacts on the natural spring Chinook salmon population under the Proposed Action Alternative would be greater than under the No-hatchery Alternative.

Status and Trends

The ESA-listing status and risk categories for the three natural-origin Chinook salmon populations in the Sandy River Basin are not expected to change under the Proposed Action Alternative. Impacts from the hatchery programs would not be expected to change risk categories for the tule fall Chinook salmon population or the late fall Chinook salmon population because impacts from the hatchery programs would be minor, and the majority of the limiting factors for these populations would not be affected by the proposed hatchery programs. The listing status and risk categories for the natural-origin spring Chinook salmon population would not be expected to change by the next status review, but changes to the hatchery programs that would be implemented under the Proposed Action Alternative are expected to further reduce impacts on the natural-origin spring Chinook salmon population. These impacts under the Proposed Action Alternative, though minor, would be intermediate between the No-action Alternative and the No-hatchery Alternative.

The recovery goal for the Sandy River spring Chinook salmon population would not change under the Proposed Action Alternative (Subsection 1.6, Relationship to Other Plans and Policies) (ODFW 2010a; NMFS 2013c). The natural-origin Sandy River spring Chinook salmon population would continue to be identified as a core and genetic legacy population with a recovery target of high probability of persistence (score of 3). Under the Proposed Action Alternative, as with the No-action Alternative, the recovery recommendations specific to the Sandy spring Chinook salmon program would be implemented, as would the general recommendations for hatchery programs.

The operation of the hatchery programs under the Proposed Action Alternative would not be expected to have any impact on the anchor habitat or spawning areas for Sandy River spring Chinook salmon though the operation of the weirs in the Zigzag River and Salmon River impact their use by the natural-origin spring Chinook salmon population. Under these alternatives, the essential physical and biological features affecting freshwater spawning, freshwater rearing, and freshwater migration that were designated as critical habitat for the LCR Chinook Salmon ESU

in the action area would continue to be affected by hatchery operations, weirs, or intake structures (Subsection 3.3.1, Sandy River Spring Chinook Salmon). However, the impacts from the operation of the hatchery program on critical habitat are not expected to occur because the hatchery program does not directly impact habitat. As under the No-action Alternative, the weirs would be expected to have a minor impact on the habitat because they are temporary, disturb a limited area, and are operated to minimize delay in migration.

Limiting Factors and Threats

As with the other alternatives, the Proposed Action Alternative would not add or detract from the effect of the changes that have occurred in resource development and municipal water supply and hydropower development and thus, their effects would continue as described in Subsection 3.3.1, Sandy River Spring Chinook Salmon. However, the effects of the spring Chinook salmon program on the Sandy River spring Chinook salmon population would be expected to be reduced relative to the No-action Alternative because natural-origin adults would be used in the broodstock, and in the near term fewer hatchery juveniles would be released. These impacts would be greater than what would occur under the No-hatchery Alternative.

Effects of Hatchery Programs

The seven factors used to evaluate the effects of hatchery programs on the natural-origin populations identified in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, are reviewed below under the Proposed Action Alternative with comparisons to the No-action Alternative.

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

Potential impacts from the removal of natural-origin adults for broodstock are described in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. Under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative, natural-origin spring Chinook salmon would not be used for broodstock and, thus, there would be no effect from broodstock removal on the natural-origin spring Chinook salmon population. Under the Proposed Action Alternative, up to 20 percent of the broodstock would be from the natural-origin spring Chinook salmon population. At the 132,000 smolt release level this would be 22 natural-origin adults, and under the 300,000 smolt release 42 natural-origin adults would be needed. As described in Subsection 2.4.1, Sandy River Spring Chinook Salmon Program, to reduce demographic impacts, the natural-origin male spring Chinook salmon would be live-spawned and then returned to the Sandy River Basin to potentially spawn again (Groot and Margolis 1991). No more than 2 percent of the natural-origin spring Chinook salmon returning to the Sandy River Basin would be used for hatchery broodstock under the Proposed Action Alternative, which compares to no natural-origin adults being used in the broodstock under the No-action Alternative. For example, if the annual return size is 650 spring Chinook salmon, no more than 13 males (2 percent) would be removed for hatchery broodstock purposes. Based on the recent 10-year average, which was 1,645 natural-origin adult returns to the Sandy River Basin, only 22 males would be removed to produce 132,000 smolts; this represents only 1.3 percent of the natural-origin returns. The escapement of natural-origin spring Chinook salmon at

the weirs would be monitored to ensure that the runsize is such that the collection of natural-origin male spring Chinook salmon would not exceed 2 percent of the final estimated natural-origin population.

Under the Proposed Action Alternative, the removal of male spring Chinook salmon would have a negligible effect on the natural-origin population because male spring Chinook salmon typically outnumber females, and there are a sufficient number to spawn naturally even after the removal of 22 males for hatchery broodstock. For example, data for the Sandy River in 2012 and 2013 show that natural-origin male spring Chinook salmon handled at the Zigzag River and Salmon River weirs made up 59.5 percent of the natural-origin population above the weirs. Using these same numbers, by removing 22 males to produce 132,000 smolts, the proportion of male spring Chinook salmon would decrease from 59.5 percent to 58.9 percent. By removing 42 males to produce a release of 300,000 smolts, the proportion of natural-origin males on the spawning grounds would decrease to from 59.5 percent to 58.3 percent. Under the other three alternatives, natural-origin spring Chinook salmon would not be collected for broodstock and thus the minor impacts from removing a small number of male Chinook salmon for broodstock would not occur.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential impacts from genetic effects are described under Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. Effects under the No-action Alternative are described in Subsection 4.3.1.1, Sandy River Spring Chinook Salmon. Genetic effects under the Proposed Action Alternative would differ from those expected under the No-action Alternative and the Reduced Production Alternative because natural-origin adults would be incorporated into the spring Chinook salmon broodstock reducing the risk of hatchery-influenced selection. However, the number of smolts released would vary depending on performance measures, and potentially could be less than under the No-action Alternative, but still greater than the Reduced Production Alternative. This analysis, therefore, places effects of the Proposed Action Alternative related to the number of hatchery adults on the spawning grounds in the middle range among these alternatives. As compared to the No-hatchery Alternative, genetic effects would be greater under the Proposed Action Alternative because hatchery spring Chinook salmon could still contribute to the naturally spawning population. The goal for the program is to incorporate enough natural-origin males such that pNOB is 20 percent, and the pHOS goal would remain at 10 percent. By incorporating natural-origin fish into the broodstock, PNI becomes a useful metric to assess risk of hatchery-influenced selection on the natural-origin spring Chinook salmon population.

The HSRG (2014)recommends a PNI level of 0.67, or higher, for populations to reach a low risk or very low risk status (Subsection 4.1, Potential Hatchery Effects). NMFS analyzed annual PNI values for return years 2008 through 2013 (Table 6). Because only hatchery adults were used for broodstock in 2011, 2012, 2013, and 2014 (i.e., pNOB was 0) PNI would decline to lower levels for return years 2016 and 2018. Under the Proposed Action Alternative, natural-origin adults would be used for broodstock beginning with the 2015 broodyear and, with the expectation that pHOS would remain less than 10 percent, then PNI would exceed 0.66 in return year 2020, and remain above that level, consistent with the HSRG guidelines (HSRG 2009a;

2014). Under the Proposed Action Alternative, genetic effects caused by hatchery-influenced selection are expected to be minor and would not be expected to affect the recovery of the natural-origin spring Chinook salmon population in the Sandy River (Subsection 4.3, Effects on Anadromous Fish Listed under the ESA). These genetic effects would be less than under the No-action Alternative and the Reduced Production Alternative because the number of natural fish incorporated into the broodstock, and therefore PNI, would be greater under the Proposed Action Alternative. Adverse genetic effects on spring Chinook salmon caused by hatchery-influenced selection would be eliminated under the No-hatchery Alternative.

Under the Proposed Action Alternative, the production level would begin at 132,000 smolts with the expectation that the pHOS goal of 10 percent would be achieved. If monitoring shows that the 10 percent goal is being achieved, then production would incrementally increase over time up to a maximum of 300,000 smolts, equivalent to the No-action Alternative. A pHOS of 9.3 percent was achieved in 2013 from releases that exceeded the proposed 132,000 smolt release, and on that basis alone it would be expected that in the following years a pHOS of less than 10 percent should remain achievable under the Proposed Action Alternative. The measures that were implemented to lower pHOS under the No-action Alternative would continue under the Proposed Action Alternative. Under the Proposed Action Alternative, the proposed production level and the release of all production at the Bull Run acclimation pond would increase the probability that the goal of less than 10 percent pHOS would be achieved. The probability of reducing pHOS under the Proposed Action Alternative would be greater than under the No-action Alternative, which would release more hatchery smolts, and less than under the Reduced Production Alternative, which would release fewer hatchery smolts. Under the No-hatchery Alternative, pHOS would go to approximately zero because no hatchery smolts would be released. Regardless, it is expected that the Proposed Action Alternative would meet the pHOS goal of 10 percent. Support for the less-than-10 percent pHOS goal is discussed in Subsection 4.3.1.1, Sandy River Spring Chinook Salmon.

Under the Proposed Action Alternative, the weirs would be operated as described under the No-action Alternative, and the effects would be expected to be the same. To ensure that the effects of the weirs remain low, monitoring of the spring Chinook salmon escapement and spawning would continue under the Proposed Action Alternative as under the No-action Alternative. As described under the No-action Alternative and the Reduced Production Alternative, if the acclimation and release of all of the hatchery spring Chinook salmon at the Bull Run acclimation pond reduces the proportion of hatchery spring Chinook salmon reaching to the upper Sandy River Basin, such that pHOS would be less than 10 percent, even if these hatchery adults were not trapped and removed at the upper basin weirs, it would be possible to stop operating the Zigzag River and Salmon River weirs, reducing the potential for impacts from weir rejection, migration delay, and delayed mortality from handling at the traps.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery spring Chinook salmon are expected to have a negligible

effect on natural-origin juveniles under the No-action Alternative, and would have an even lower effect under the Proposed Action Alternative because fewer hatchery juveniles would be released initially. However, if production increases to the maximum level of 300,000 smolts, the effects would be expected to be the same as under the No-action Alternative, remaining low.

These potential impacts from ecological interactions would occur where hatchery smolts interact with natural-origin juveniles during the downstream migration, and if hatchery juveniles residualize and do not emigrate. The potential impacts from competition between hatchery juveniles, the progeny of naturally spawning hatchery fish, and natural-origin juveniles in the action area would be expected to be less than what would occur under the No-action Alternative because there would be fewer hatchery juveniles released under the Proposed Action Alternative. As a result, the effects of these ecological interactions are expected to be low, because the hatchery spring Chinook salmon juveniles would be released at a size and physiological state that leads to rapid emigration from the basin, released at location in the lower basin away from natural production areas, and monitored to determine if adverse interactions are occurring.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, this factor is not a threat. Under the Proposed Action Alternative, as under the Reduced Production Alternative, any potential impact would be less than that under the No-action Alternative because there would be fewer juveniles released. However, if production under the Proposed Action Alternative increases to the maximum level of 300,000 smolts, the potential impacts would be same as those under the No-action Alternative. Under the No-hatchery Alternative, any potential density-dependent effects in the migration corridor from the release of hatchery fish in the Sandy River would not be expected to occur because juvenile hatchery fish would no longer be released in the Sandy River Basin.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

As under the No-action Alternative, ME&R activities to evaluate the hatchery program would be expected to continue (e.g., hatchery juvenile presence and absence in lower mainstem Sandy River) under the Proposed Action Alternative. Additionally, monitoring and evaluation activities (e.g., spawning ground surveys) in the Sandy River Basin to monitor the status and recovery of the listed populations in the basin (Subsection 2.1.1, Sandy River Spring Chinook Salmon Program) and as part of the Bull Run Water Supply HCP would also continue (Subsection 1.6, Relationship to Other Plans and Policies) (NMFS 2008b).

These monitoring and evaluations activities would continue to impact listed species due to the handling of listed adults and juveniles and from the operation of a screw trap in Cedar Creek to monitor the recolonization of habitat above the Sandy Hatchery. All of these activities would be consistent with the general guidelines developed by NMFS to reduce impacts when collecting adults and juveniles, but impacts would be expected to occur under all of the action alternatives.

However, these impacts would be expected to be minimal based on effects observed from recent ME&R activities.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the hatchery programs would continue to have a negligible effect on ESA-listed species under the Proposed Action Alternative. Under the Proposed Action Alternative, no new construction at the Sandy Hatchery would occur and thus, no effects would be expected. Water intake structures and water withdrawal present another set of potential effects on listed salmonids, and these were evaluated in Subsection 4.2, Effects on Water Quality and Water Quantity.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The release of hatchery fish to support these fisheries would occur under the Proposed Action Alternative, but fewer hatchery adults would be expected to be available compared to the No-action Alternative because few hatchery juveniles would be released. However, if production under the Proposed Action Alternative increases to the maximum level of 300,000 smolts, the potential number of returning hatchery spring Chinook salmon would be same as those under the No-action Alternative. The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsection 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

4.3.4.2. Sandy River Coho Salmon

Subsection 3.3.2, Sandy River Coho Salmon, describes populations that are part of the LCR Coho salmon ESU including the Sandy River coho salmon population. All of the other coho salmon populations and their associated habitat reside outside the action area and would not be affected under the Proposed Action Alternative.

Life History

Under the Proposed Action Alternative, the hatchery coho salmon program could impact the life history characteristics of the natural-origin coho salmon population, but these impacts are expected to be minimal over the near term. NMFS (2003a) determined that the Sandy River hatchery coho salmon program was no more than moderately diverged from the natural population in the watershed and that the stock was derived from the local, natural-origin population. It was not considered to be minimally divergent because the hatchery program did not incorporate substantial numbers of natural-origin fish into the broodstock. Based on this determination, NMFS considers the hatchery program to be integrated with the natural population. Over the long term, impacts of the coho salmon program on the life history

characteristics of the natural-origin coho salmon population under the No-action Alternative may increase because natural-origin coho salmon are not used for broodstock and therefore, if the hatchery coho salmon continuing to interbreed with the natural population, adverse genetic effects would eventually be expected to accrue. The impact of hatchery coho salmon interbreeding with the natural population would be expected to decrease under the Proposed Action Alternative as compared to the No-action Alternative because fewer hatchery fish would be released, reducing the potential number of hatchery adults that spawn naturally, and achieving the lower pHOS goal of 5 percent would reduce adverse genetic effects. The impacts on the natural coho salmon population under the Proposed Action Alternative would be greater than under the Reduced Production Alternative because more hatchery coho salmon would be released (300,000 smolts under the Proposed Action Alternative compared to 222,000 smolts under the Reduced Production Alternative). Under the No-hatchery Alternative, effects of the hatchery coho salmon program would cease.

Status and Trends

The status and biological risk categories identified in Ford (2011) concluded that the LCR Coho Salmon ESU is at very high risk of extinction; however, the Sandy River coho salmon population was considered to be at high to moderate risk of extinction. ODFW (2010a) determined that the Sandy River coho salmon population abundance and productivity parameter had decreased relative to that observed by McElhany et al. (2007), and this contributed to the lowering of the overall status to high risk (Figure 8). The listing status and risk categories for the natural-origin coho salmon population would not be expected to change by the next status review, but changes to the hatchery programs that have been implemented under the No-action Alternative are expected to further reduce impacts on the natural-origin coho salmon population. These hatchery changes along with factors affecting VSP parameters have changed since these determinations, and these changes may improve the overall status of the population over the long term. However, the hatchery program poses risks under the No-action Alternative due to naturally spawning hatchery fish, but these risks are minor These risks would be expected to be less under the Proposed Action Alternative because fewer hatchery adults would be returning that could potentially interbreed with natural-origin coho salmon. These impacts, though minor, would be greater than under the Reduced Production Alternative; these impacts would not occur under the No-hatchery Alternative. To the extent that adverse impacts on Sandy River coho salmon populations under the No-action Alternative and the Proposed Action Alternative are reduced, it would be expected that the productivity of the natural-origin population would increase, leading to more adults returning to the Sandy River Basin compared to current levels (Table 5).

The recovery goal for the Sandy River coho salmon population would not change under the Proposed Action Alternative (Subsection 1.6, Relationship to Other Plans and Policies)(ODFW 2010a; NMFS 2013c). The natural-origin Sandy River coho salmon population would continue to be identified as key to recovery of the Cascade coho salmon strata and the LCR coho salmon ESU with a target of high probability of persistence (score of 3). Under the Proposed Action Alternative, as under the No-action and Reduced Production Alternatives, the recovery recommendations specific to the Sandy coho salmon program would be implemented, as would the general recommendations for hatchery programs.

The operation of the hatchery programs under the Proposed Action Alternative would not be expected to have any impact on the anchor habitat or spawning areas for Sandy River coho salmon though the operation of the tributary weirs, and the adult weir at the Sandy Hatchery may impact use by the natural-origin coho salmon population. These effects would not occur under the No-hatchery Alternative.

Limiting Factors and Threats

As under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative, the Proposed Action Alternative would not add or detract from the effect the changes that have occurred to the impacts from resource development and municipal water supply and hydropower development, and thus their effects would continue as described in Subsection 3.3.2, Sandy River Coho Salmon. However, the effects of the coho salmon program on the Sandy River coho salmon population would be expected to be reduced relative to the No-action Alternative because fewer hatchery adults would be produced and the pHOS goal would be reduced to 5 percent.

Effects of Hatchery Programs

The seven factors used to evaluate the effects of hatchery programs on the natural-origin populations identified in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, are reviewed below under the Proposed Action Alternative with comparisons to the No-action Alternative.

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

Potential impacts from the removal natural-origin adults for broodstock are described in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. As under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative, natural-origin coho salmon would not be used for broodstock under the Proposed Action Alternative and, thus, there would be no effect on the natural-origin coho salmon population.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential impacts from genetic effects are described under Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. Effects under the No-action Alternative are described in Subsection 4.3.1.2, Sandy River Coho Salmon. Genetic effects under the Proposed Action Alternative as under the Reduced Production Alternative would be expected to be low because the program would be operated such that the pHOS goal would be less than 5 percent, compared to the No-action Alternative where the pHOS goal would be less than 10 percent.
The reduction in effects between the 5 percent pHOS goal and 10 percent pHOS goal would be expected to be minor, even though the 5 percent goal would meet the HSRG (2014) recommended pHOS for segregated programs. The HSRG (2014) identified that segregated programs may require a pHOS goal that is lower than 5 percent because, even at this level,

reducing the risks from hatchery-influenced selection may be insufficient to safeguard the viability of the natural-origin population. As under the Reduced Production Alternative, under the Proposed Action Alternative, the effects on the natural-origin population from hatchery-influenced selection would be even less than the 5 percent pHOS goal would indicate, but the impacts from the Proposed Action would be expected to be slightly greater because more hatchery adults would be expected to return under the Proposed Action Alternative than under the Reduced Production Alternative, but still less than the No-action Alternative (Table 2).

The 5 percent pHOS goal would be expected to lower risk under the Proposed Action Alternative to an acceptable level, because, as described under the evaluation of the No-action Alternative, the HSRG makes no distinction between hatchery programs using broodstock from outside the ESU/DPS and those programs that were derived from the local natural-origin population, only indicating that the impacts would be greater given the more divergence between the hatchery and natural-origin populations. This is in contrast to the ICTRT (2007a), which showed decreasing risk to the natural population depending on the source of the hatchery spawners and how the hatchery programs was operated (Figure 13). In Figure 13, the bottom graph would represent a hatchery program that was integrated, and the graph immediately above it would represent a hatchery program that was segregated but was derived from the natural-origin population (ICTRT 2007a). For this latter group, a pHOS of 5 percent would pose a low risk to the viability of the natural population over a longer period than a pHOS of 10 percent, but would be a moderate risk over the long term.

Furthermore, the less-than-5 percent pHOS goal that the HSRG recommends is the value that its modeling shows would limit the influence of the segregated hatchery program on the viability of the natural-origin population after many generations. The HSRG model also assumes that spawning between hatchery and natural-origin adults is completely random, where the chances of all three types of crosses (HxH, HxN, and NxN) are equally likely to occur. If this assumption was correct, then based on the analysis of the mating-frequency in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, and in Figure 14, a pHOS level of 5 percent (0.05) should result in approximately 90 percent of the matings being NxN, 9 percent being NxH, and less than 1 percent being HxH. This would ensure that 9 out of 10 matings would be NxN, which would limit impacts on the natural-origin population from hatchery-influenced selection. The actual level of HxN would probably be substantially less under the Reduced Production Alternative because there would be fewer returning hatchery adults and the hatchery adults tend to be distributed lower in the Sandy River Basin away from the natural spawning areas.

Ultimately, although impacts from hatchery-influenced selection would occur under the Proposed Action Alternative and the Reduced Production Alternative, as discussed above, these impacts are expected to be of small magnitude. In contrast, any adverse impacts would not be expected to occur beyond the first few years under the No-hatchery Alternative because the coho salmon program would be terminated, and adult returns would eventually cease.

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

The most important effects considerations under Factor 3 are competition and predation by juvenile hatchery fish and the progeny of naturally spawning hatchery fish, and premature

emigration of natural-origin fish caused by hatchery fish. Hatchery smolts and the juvenile progeny of naturally spawning hatchery coho salmon are expected to have a negligible effect on natural-origin juveniles under the No-action Alternative, and would have an even lower effect under the Proposed Action Alternative because few hatchery juveniles would be released.

These potential impacts from ecological interactions would occur where hatchery smolts interact with natural-origin juveniles during the downstream migration, and if hatchery juveniles residualize and do not emigrate. The potential impacts from competition between hatchery juveniles, the progeny of naturally spawning hatchery fish, and natural-origin juveniles in the action area would be expected to be less than what would occur under the No-action Alternative because there would be fewer hatchery juveniles released under the Proposed Action Alternative. However, the impact would be greater than that expected under the Reduced Production Alternative because more smolts would be released under the Proposed Action Alternative. These impacts would not occur under the No-hatchery Alternative because hatchery fish would no longer be released into the Sandy River Basin, and juvenile fish from outside the action area would not be expected to move into the Sandy River Basin.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, this factor is not a threat. Under the Proposed Action Alternative, any potential impact would be less than under the No-action Alternative because there would be fewer juveniles released, and would be expected to low if at all measurable. However, the impact would be greater than that expected under the Reduced Production Alternative because more smolts would be released under the Proposed Action Alternative. Under the No-hatchery Alternative, any potential density-dependent effects in the migration corridor from the release of hatchery fish in the Sandy River would not be expected to occur because juvenile hatchery fish would no longer be released in the Sandy River Basin.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

As under the No-action Alternative, ME&R activities to evaluate the hatchery program would be expected to continue (e.g., hatchery juvenile presence and absence in lower mainstem Sandy River) under the Proposed Action Alternative. Additionally, monitoring and evaluation activities (e.g., spawning ground surveys) would continue in the Sandy River Basin to monitor the status and recovery of the listed populations in the basin (Subsection 2.1.2, Sandy River Coho Salmon Program) and as part of the Bull Run Water Supply HCP would be expected to continue (Subsection 1.6, Relationship to Other Plans and Policies) (NMFS 2008b).

These monitoring and evaluations activities would continue to impact listed species due to the handling of listed adults and juveniles and from the operation of a screw trap in Cedar Creek to monitor the recolonization of habitat above the Sandy Hatchery. All of these activities would be consistent with the general guidelines developed by NMFS to reduce impacts when collecting

adults and juveniles, but impacts would be expected to occur under all of the action alternatives. However, these impacts on natural-origin fish would be expected to be minimal based on effects observed from recent ME&R activities.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

The construction, operation, and maintenance of hatchery facilities associated with the hatchery programs would continue to have a negligible effect on ESA-listed species under the Proposed Action Alternative. Under the Proposed Action, no new construction at the Sandy Hatchery would occur and thus, no effects would be expected. Water intake structures and water withdrawal present another set of potential effects on listed salmonids, and these were evaluated in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The release of hatchery fish to support these fisheries would occur under the Proposed Action Alternative, but fewer hatchery adults would be expected to be available compared to the No-action Alternative because fewer hatchery juveniles would be released. The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsections 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

4.3.4.3. Sandy River Winter Steelhead

Subsection 3.3.3, Sandy River Winter Steelhead, describes populations that are part of the LCR Steelhead DPS, including the Sandy River winter steelhead population. All of the other steelhead populations and their associated habitat reside outside the action area and would not be affected under the Proposed Action Alternative.

Life History

The life history characteristics of the winter steelhead population in the Sandy River would not be expected to change under the Proposed Action Alternative or the No-action Alternative. As described in Subsection 3.3.3, Sandy River Winter Steelhead, summer steelhead are not native to the Sandy River Basin, but impacts from the release of hatchery summer steelhead can have effects on the Sandy River winter steelhead population. The winter steelhead and summer steelhead hatchery programs may impact the life history characteristics of the natural-origin winter steelhead population, but these impacts are expected to be minimal because the hatchery winter steelhead were derived from the natural-origin Sandy River winter steelhead population, and the program has incorporated natural-origin winter steelhead into the broodstock to maintain similarities between the hatchery and natural-origin winter steelhead. However, over the long term, the winter steelhead program under the No-action Alternative and the Reduced Production

Alternative may impact the life history characteristics of the natural-origin winter steelhead population because natural-origin winter steelhead are no longer used for broodstock and as a result of the hatchery winter steelhead continuing to interbreed with the natural population.

The impact of hatchery winter steelhead interbreeding with the natural population would be expected to less than what would be observed under the Reduced Production Alternative even though fewer hatchery fish would be released because those hatchery adults that do spawn naturally would be more representative of the natural-origin population than those produced under the Reduced Production Alternative. The impacts on the natural winter steelhead population under the Proposed Action Alternative, though minor, would be greater that under the No-hatchery Alternative because hatchery fish would not be released if hatchery programs are terminated.

Status and Trends

The status and biological risk categories identified in Ford (2011) concluded that the LCR Steelhead DPS is at very high risk of extinction, and the Sandy River winter steelhead population was considered to also be at high to moderate risk of extinction. Under the No-action Alternative, the hatchery programs would not be expected to change the listing status and risk categories for the natural-origin winter steelhead population by the next status review but, changes to the hatchery programs that have been implemented under the No-action Alternative and would continue under the Proposed Action Alternative would be expected to further reduce impacts on the natural-origin winter steelhead population. These hatchery changes along with factors affecting VSP parameters have changed since these determinations and these changes may improve the overall status of the population over the long term. However, the hatchery program would continue to pose risks under the No-action Alternative due naturally spawning hatchery fish but these risks are minor. These risks would be expected to be less under the Proposed Action Alternative because the hatchery adults that would be returning would be more representative of the natural-origin population than under either the No-action Alternative or under the Reduced Production Alternative. To the extent that adverse impacts on Sandy River coho salmon populations that would accrue under the No-action Alternative and the Proposed Action Alternative are reduced, it would be expected that the productivity of the natural-origin population would increase, leading to more adults returning to the Sandy River Basin compared to current levels (Table 5).

The recovery goal for the Sandy River winter steelhead population would not change under the Reduced Production Alternative (Subsection 1.6, Relationship to Other Plans and Policies)(ODFW 2010a; NMFS 2013c). The natural-origin Sandy River winter steelhead population would continue to be identified as a core population with a recovery target of very high probability of persistence (less than 1 percent chance of extinction or a persistence score of 4)(Table 4). Summer steelhead are not indigenous and, therefore, there is not a recovery goal for these fish. Under the No-action Alternative and the Proposed Action Alternative, the recovery recommendations specific to the Sandy winter steelhead program would be implemented, as would the general recommendations for hatchery programs (ODFW 2010a; NMFS 2013c). The operation of the hatchery programs under the No-action Alternative and the Proposed Action Alternative would not be expected to have any impact on spawning habitat for winter steelhead

in the action area including those areas designated as critical habitat (Table 1). The specific PCEs in the action area – freshwater spawning, freshwater rearing, and freshwater migration – would not be adversely impacted by the hatchery programs, though the operation of the weir at the Sandy Hatchery would briefly delay upstream migration for natural-origin winter steelhead returning to Cedar Creek.

Limiting Factors and Threats

As under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative, the Proposed Action Alternative would not add or detract from the effect the changes that have occurred to the impacts from resource development and municipal water supply and hydropower development, and thus, their effects would continue as described in Subsection 3.3.3, Sandy River Winter Steelhead. However, the effects of the steelhead programs on the Sandy River winter steelhead population would be expected to be reduced relative to the No-action Alternative because the returning hatchery adults would be more representative of the natural-origin population, thereby reducing risk.

Effects of Hatchery Programs

The seven factors used to evaluate the effects of hatchery programs on the natural-origin populations identified in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA, are reviewed below under the Proposed Action Alternative with comparisons to the No-action Alternative.

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

Potential impacts from the removal of natural-origin adults for broodstock are described in Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. Under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative, natural-origin winter steelhead would not be used for broodstock and thus, there would be no effect on the natural-origin winter steelhead population.

Under the Proposed Action Alternative, up to 20 percent of the broodstock would be from the natural-origin winter steelhead population. As described in Subsection 2.4.3, Sandy River Winter Steelhead Program, the program would include up to 26 natural-origin male winter steelhead in the broodstock annually (a pNOB of approximately 20 percent), and the number collected would be limited such than no more than 2 percent of the natural-origin adult winter steelhead returning to the Sandy River would be retained for broodstock. The escapement of natural-origin winter steelhead would be monitored during winter steelhead spawning surveys to ensure that the winter steelhead escapement is such that broodstock collection would not exceed 2 percent of the natural-origin population.

The removal of only male natural-origin fish would limit effects on the naturally spawning population. To reduce demographic impacts further, the male natural-origin winter steelhead would be live-spawned and then released back into the Sandy River so they could potentially spawn naturally.

The removal of less than 2 percent of the population for broodstock could be compared to an additional harvest of the Sandy River winter steelhead population. Using this harvest analogy, Chilcote (2001) performed a series of Population Viability Analysis (PVA) model runs for 27 steelhead populations to assess the impact of harvest on the status and recovery of steelhead in Oregon. For most populations the modeling exercise suggested that the probability of extinction was essentially 0 as long as mortality rates associated with harvest remained less than 30 percent. However, when mortality rates became greater than 40 percent, the probability of extinction increased dramatically. In addition, once the probability of extinction increased beyond 0.05, the transition to an extinction probability of 1.00 was rapid. Because the transition from low risk to high risk happens so rapidly, there is little room for error (in either the model or the measurement of mortality rates). To address this concern, ODFW set a maximum fisheries impact limit of 20 percent, under the conservative assumption that this would provide a reasonable contingency for errors, even though the model results suggest that management under a 30 percent limit was unlikely to cause extinction. The impact of freshwater fisheries on natural-origin winter steelhead is expected to range from 0.5 to 2.5 percent of the natural-origin returns (ODFW 2003). The less than 2 percent additional impact from the removal of 26 natural-origin male winter steelhead in addition to the impacts from the freshwater fisheries is expected to be less than 5 percent annually, which is substantially below the maximum fisheries impact limit of 20 percent.

Based on the estimated abundance of natural-origin winter steelhead in 2013 and the preliminary estimate for return year 2014 (Table 5), the 26 winter steelhead that would have been taken for broodstock under the Proposed Action Alternative represent less than 1 percent of the natural-origin winter steelhead population.

Factor 2. Hatchery fish and progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adults collection facilities

Potential impacts from genetic effects are described under Subsection 4.3, Effects on Anadromous Fish Listed under the ESA. Effects under the No-action Alternative are described in Subsection 4.3.1.3, Sandy River Winter Steelhead. Genetic effects under the Proposed Action Alternative would be less than those expected under the No-action Alternative and the Reduced Production Alternative because natural-origin adults would be incorporated into the winter steelhead broodstock.

Under the Proposed Action Alternative, the winter steelhead program would be managed as an integrated program, with a pNOB of 20 percent (0.2), and a pHOS goal of less than10 percent (0.1), for a PNI of 0.67, based on a 3-year moving average. These criteria meet the recommendations of the HSRG (2014) for an integrated program impacting a population of high conservation value (one with very low risk of extinction). PNI is expected to reach 0 in return years 2014 to 2016 as returns from broodyears 2012, 2013, and 2014 make up the majority of the returning adults, and in these broodyears only returning hatchery winter steelhead were used for broodstock. However, PNI would be expected to increase to 0.67 in the future when adults produced under the Proposed Action Alternative return to the basin and pHOS would be maintained at less than 10 percent.

Under the Proposed Action Alternative, the passage of natural-origin winter steelhead into the upper Cedar Creek Basin would be operated as described under the No-action Alternative. Only natural-origin adults would be passed until 2019 at which time an evaluation of the smolt production from the adults released above the hatchery would be used to determine if hatchery origin winter steelhead would be used to supplement the natural-origin population. Under the Proposed Action Alternative, risks would be same as under the No-action Alternative and the Reduced Production Alternative, but marginally greater than the No-hatchery Alternative because mis-marked hatchery steelhead could be mistaken for natural-origin winter steelhead and passed above the hatchery. This would not occur under the No-hatchery Alternative because the hatchery program would be terminated.

Under the Proposed Action Alternative, impacts from the handling of natural-origin winter steelhead at the hatchery weir would be same as under the No-action Alternative and the Reduced Production Alternative, as would the handling of unmarked summer steelhead adults. The impacts from handling adults are expected to remain at the low levels currently observed. These impacts would not occur under the No-hatchery Alternative because the weirs would not be operated to collected broodstock and remove hatchery adults.

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

Under the Proposed Action Alternative, competition and predation due to interactions between juvenile hatchery fish (including earlier emigration, residualized hatchery juveniles, and downstream of the hatchery and acclimation pond) would be expected to have the same small effect on natural-origin juveniles that would occur under the No-action Alternative, but a slightly greater effect than under the Reduced Production Alternative because there would be fewer hatchery juveniles released under the Reduced Production Alternative. These impacts would not occur under the No-hatchery Alternative because hatchery fish would no longer be released into the Sandy River Basin, and juvenile fish from outside the action area would not be expected to move into the Sandy River Basin.

Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor

Best available information does not indicate that the release of hatchery fish from the Sandy River programs under the No-action Alternative would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, this factor is not a threat. Under the Proposed Action Alternative and the Reduced Production Alternative, any potential impact would be less than that under the No-action Alternative because there would be fewer juveniles released. Under the No-hatchery Alternative, any potential density-dependent effects in the migration corridor from the release of hatchery fish in the Sandy River would not be expected to occur because juvenile hatchery fish would no longer be released in the Sandy River Basin.

Factor 5. Monitoring, Evaluation, and Research (ME&R) that exists because of the hatchery program

As under the No-action Alternative, ME&R activities to evaluate the hatchery program would be expected to continue (e.g., hatchery juvenile presence and absence in lower mainstem Sandy River) under the Proposed Action Alternative. Additionally, monitoring and evaluation activities (e.g., spawning ground surveys) would continue in the Sandy River Basin to monitor the status and recovery of the listed populations in the basin (Subsection 2.1.3, Sandy River Winter Steelhead Program) and as part of the Bull Run Water Supply HCP (Subsection 1.6, Relationship to Other Plans and Policies) (NMFS 2008b).

These monitoring and evaluations activities would continue to impact listed species due to the handling of listed adults and juveniles and from the operation of a screw trap in Cedar Creek to monitor the recolonization of habitat above the Sandy Hatchery. All of these activities would be consistent with the general guidelines developed by NMFS to reduce impacts when collecting adults and juveniles, but impacts would be expected to occur under all of the action alternatives. However, these impacts on natural-origin fish would be expected to be minimal based on effects observed from recent ME&R activities.

Factor 6. The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program.

The construction, operation, and maintenance of hatchery facilities associated with the hatchery programs would continue to have a negligible effect on ESA-listed steelhead under the Proposed Action Alternative. Under the Proposed Action, no new construction at the Sandy Hatchery would occur and no effects would be expected as a result of construction. Water intake structures and water withdrawal potential effects on listed salmonids were evaluated in Subsection 4.2, Effects on Water Quality and Water Quantity.

Factor 7. Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Fisheries in the Sandy River Basin and their management are not included as part of the No-action Alternative. Fisheries targeting hatchery fish produced under the No-action Alternative were described and evaluated in separate opinions (NMFS 2003b; 2008c; 2008g). The release of hatchery fish to support these fisheries would occur under the Proposed Action Alternative, but fewer hatchery adults would be expected to be available compared to the No-action Alternative because few hatchery salmon juveniles would be released. The effects of fisheries targeting hatchery produced adults on the human environment under the different alternatives are analyzed in Subsection 3.7, Socioeconomics, and Subsection 3.8, Tourism and Recreation.

4.3.4.4. Columbia River Chum Salmon

Life History

The presence of hatchery programs under the Proposed Action Alternative would be expected to have no effect on Sandy River chum salmon, including its life history, because chum salmon are not currently present in the Sandy River. In the future, if chum salmon are reintroduced or recolonize habitat in the Sandy River, the hatchery programs under the No-action Alternative would be expected to impact chum salmon. Under the Proposed Action Alternative, these impacts would be expected to be less because fewer hatchery juveniles would be released. Under the No-hatchery Alternative these impacts would not occur because the hatchery programs would be terminated. As described in Subsection 3.3.4, Columbia River Chum Salmon, the survival and growth in juvenile chum salmon depends less on freshwater conditions than on favorable estuarine and ocean conditions. These factors are outside the action area and would not be affected by the hatchery programs.

Status and Trends

Sandy River chum salmon are extirpated and no actions have been identified to actively reintroduce chum salmon into the basin.

Limiting Factors

Within the Sandy River, ODFW (2010a) identified the secondary limiting factors as including impaired upstream passage, altered hydrology, and excessive fine sediment limiting the viability of the natural population. Barriers at road crossings, including culverts on Beaver and Buck Creeks in the lower Sandy River watershed, could impede chum salmon passage in several lower Sandy River tributaries. The hatchery programs under the No-action Alternative, No-hatchery Alternative, and Reduced Production Alternative would not have an effect on these limiting factors. Critical habitat designated for the Columbia River Chum Salmon ESU did not include the Sandy River Basin (Table 1).

The recovery goal for the Sandy River population of chum salmon, as described in the Recovery Plan (ODFW 2010a), is for the population to be at low risk of extinction (less than 5 percent probability) and would not change under any of the alternatives. An annual abundance goal was not established for this population. There are no specific hatchery actions to address impacts of the Sandy River Hatchery programs on chum salmon, other than improving passage at the hatchery intake and adult weir on Cedar Creek, which has been completed.

If chum salmon were present in the Sandy River, impacts may occur as a result of the Proposed Action Alternative, Reduced Production Alternative, and the No-action Alternative from interactions with juvenile hatchery fish. The effect of these impacts on the ESA-listed chum salmon is expected to be negligible under the No-action Alternative and any action alternative because ODFW would implement the following BMPs so that hatchery fish move quickly out of the Sandy River Basin. These BMPs include rearing juveniles to the sizes and under conditions identified in the HGMPs, i.e., continuing to mark all hatchery juveniles, and acclimating hatchery juveniles prior to release. In addition, ODFW would verify with monitoring the

presence of hatchery juveniles in the lower Sandy River as part of the juvenile outmigration monitoring under Proposed Action Alternative, Reduced Production Alternative, and the No-action Alternative; results would be reported annually.

4.3.4.5. Pacific Eulachon

Life History

The presence of hatchery programs under the Proposed Action Alternative would be expected to have an adverse impact on eulachon in the Sandy River, but this impact would likely be smaller than under the No-action Alternative, because fewer hatchery juveniles would be released, and intermediate between the No-action and the Reduced Production Alternatives. No impacts on Pacific Eulachon would occur under the No-hatchery Alternative.

Under the alternatives, designated critical habitat in the action area would not likely be affected because it is limited to the lower Sandy River below the mouth of Gordon Creek (RM 12.8). Gordon Creek enters the Sandy River at Oxbow Park (Figure 1) and all of the facilities associated with the hatchery programs under the Proposed Action Alternative, the No-action Alternative and the Reduced Production Alternative are located in the Sandy River well above the mouth of Gordon Creek and thus would not be expected to impact Pacific eulachon habitat. The hatchery programs under the Proposed Action Alternative would not have an effect on climate change impacts on ocean habitat and other threats to the species include by-catch in shrimp trawl fisheries, climate change impacts on freshwater habitat, and habitat alteration and degradation from a variety of activities.

Status and Trends

Eulachon abundance is at or near historically low levels throughout their range, including the Sandy River (Subsection 3.3.5, Pacific Eulachon). Under the Proposed Action Alternative as with the Reduced Production Alternative and the No-action Alternative, the hatchery programs would not be expected to affect these abundance levels because predation of juvenile eulachon, by natural or hatchery juvenile salmon and steelhead, was not identified as a factor that was limiting the abundance or distribution of eulachon. If there were an impact from the hatchery programs this would be not occur under the No-hatchery Alternative because the hatchery programs would be terminated.

Limiting Factors and Threats

Because of the overlap in the lower Sandy River Basin between the emergence of juvenile eulachon in January through March and the release of hatchery juveniles from March through May, there would be a potential for predation on and competition with eulachon by hatchery salmonid juveniles under the No-action Alternative. This potential for predation and competition under the Proposed Action Alternative would be intermediate between the No-action Alternative, and the Reduced Production Alternative due to differences in the number of juveniles released. In contrast, these potential adverse impacts would not occur under the No-hatchery Alternative.

4.3.4.6. Bull Trout

The Proposed Action Alternative would have no effect on bull trout in the Sandy River Basin because few bull trout have been observed in the Sandy River Basin, and these were believed to be transitory migrants foraging during the winter months (USFWS 2014). Under the Proposed Action Alternative, as under the Reduced Production Alternative, the potential benefits from bull trout feeding on hatchery carcasses would be reduced because the hatchery production would be lower than under the No-action Alternative. This reduction could be replaced by an increase in the abundance of natural-origin salmon and steelhead adult carcasses.

4.4. Effects on Non-listed Fish

4.4.1. Alternative 1 (No-action) – Continue to Operate the Four Hatchery Programs as Described and Approved in the 2012 Biological Opinion

Under the No-action Alternative, the hatchery programs would adversely and beneficially affect non-listed fish in the Sandy River Basin in three ways: through obstruction or other behavioral effects of the structures required by the ongoing hatchery programs, through incidental impacts in fisheries targeting hatchery fish returning to the Sandy River Basin, and through ecological interactions.

The release of hatchery salmon and steelhead under the No-action Alternative would be expected to have either minor adverse or beneficial biological or ecological effects on non-listed fish in the Sandy River. Hatchery salmon and steelhead would be expected to adversely impact non-listed fish through competition effects and through predation, but the production of actively migrating hatchery smolts that exit rapidly out of the Sandy River would be expected to minimize competition with non-listed fish under the No-action Alternative. The release of hatchery salmon and steelhead would be expected to provide a minor benefit by providing prey for the non-listed fish.

It is also possible that lamprey in the Sandy River Basin might benefit from the additional salmon and steelhead hosts in the marine environment made available by hatchery fish under the No-action Alternative.

Lamprey may be affected adversely or beneficially by the hatchery water withdrawal system. Since 2014, lamprey have passed above the Sandy Hatchery into upper Cedar Creek. Under the No-action Alternative, water withdrawn from Cedar Creek passes through a sediment settling chamber after passing through the intake screens, but before entering the hatchery. The sediment settling basin could be considered a benefit if it provides needed habitat for rearing juvenile lamprey, or it could have an adverse effect if the sediment settling chamber traps juveniles preventing them from moving downstream. Further adverse effects could occur from handling the juveniles when cleaning out the chamber. Any adverse effect is expected to be minor because few lamprey would be handled.

There is no indication that the hatchery programs under the No-action Alternative have contributed to the absence of cutthroat trout in the Sandy River Basin. The operation of the hatchery programs would not be expected to affect the abundance of cutthroat trout. Cutthroat

trout have been found in the action area during monitoring and evaluation activities. Impacts from the handling of cutthroat trout during monitoring activities would be expected to continue under the No-action Alternative, but the effects are expected to remain minor because of the small number of fish handled.

The abundance of resident rainbow trout and whitefish in the Sandy River Basin would be affected under the No-action Alternative since hatchery-produced salmon and steelhead would continue to compete for resources with resident rainbow trout and whitefish in the action area. These effects, if any, are expected to be minor because resident rainbow trout and whitefish tend to be in the upper Sandy River Basin above the locations where hatchery juvenile salmon and steelhead are released, and the hatchery juveniles are released in such a way that they are expected to move out of the basin quickly.

Non-listed rainbow trout and whitefish may also be adversely impacted by the installation and operation of the weirs under the No-action Alternative. Adult rainbow trout and whitefish that are too large to pass through the weir pickets would be adversely impacted by delayed migration, or handling, if they enter the trap. The abundance of rainbow trout and whitefish in the Sandy River is unknown, but low (Subsection 3.4. Non-listed Fish), and they would not be expected to be present at the weirs in any substantial numbers. For example, in 2013, during the weir operations, only four white fish were recovered at the Zigzag weir, and two carcasses were recovered above the weir. No whitefish were reported at either the Salmon River or Bull Run River weirs (Lackey et al. 2013). During juvenile monitoring in 2013 under the City of Portland HCP (NMFS 2008b), only one whitefish was recovered during the monitoring activities, and this was in the Salmon River Basin (Strobel 2014). Other non-listed species in the action area tend to be found in the lower Sandy River Basin, below the locations proposed for the weirs and juvenile hatchery fish release locations; therefore, hatchery operations under the No-action Alternative would not be expected to impact these species.

The abundance of resident rainbow trout might also be expected to change or remain the same because hatchery winter steelhead that residualize and then spawn with resident trout are contributing to the abundance of resident rainbow trout, though this contribution would be expected to be minor. The magnitude of the benefit that may accrue to the resident rainbow trout population as a result of augmentation by the anadromous steelhead (both hatchery and natural-origin) would be affected by a number of factors such as instream habitat, food availability, juvenile growth, and ocean conditions that would not be affected by the proposed hatchery programs.

Under the No-action Alternative, fisheries targeting hatchery salmon and steelhead would continue, and these fisheries would impact non-listed fish. Because of the gear types and fishing methods used in salmon and steelhead fisheries, these fisheries are relatively unlikely to impact non-salmonids to any measurable degree. Under the No-action Alternative, some of the fishing effort targeting non-listed fish would have likely shifted to hatchery salmon and steelhead in the Sandy River because of their increased abundance due to the hatchery programs. This would have likely reduced slightly the fishing impact on non-listed fish. Fisheries specifically targeting non-listed fish would be expected to continue at current levels and would not change under the No-action Alternative because hatchery production would continue as in the past.

4.4.2. Alternative 2 (No hatchery) – Do Not Approve the HGMPs under Limit 5 of the 4(d) Rule

The absence of hatchery releases in the action area under the No-hatchery Alternative may result in an increase or a decrease in the abundance of non-listed fish, native and introduced, compared to current conditions. If non-listed fish are potentially harvested by ongoing fisheries targeting returning hatchery fish, even if at low levels, the absence of hatchery fish under the No-action Alternative could result in an increase in abundance for non-listed fish if it leads to a reduction in fisheries intended to target those hatchery fish. However, if the loss of fisheries targeting salmon and steelhead results in a shift of at least some of that fishing effort to non-listed fish, the result could be a minor increase in adverse fishery impacts on non-listed fish. In either case, the increase or decrease in adverse impacts on non-listed fish, while unknown, would be expected to be minor, if at all measurable.

Because lamprey are parasitic on other fish in the marine environment, it is possible that eliminating the hatchery programs could reduce the number of host fish available compared to the No-action Alternative, but to an extent that's likely negligible, since the effect would occur in the marine environment, where fish from the Sandy River represent an extremely small proportion of available hosts. The termination of the hatchery programs at the Sandy Hatchery under the No-hatchery Alternative would be expected to have either an adverse or beneficial effect on lamprey populations. The termination of the hatchery programs would eliminate the use of the sediment settling chamber by rearing juvenile lamprey, but would also eliminate any adverse impacts from the collection and transport of the juvenile lamprey when the sediment settling chamber is cleaned-out. However, either of these impacts would be expected to be minor because of the availability of other rearing habitat in the mainstem Sandy River, and the small proportion of juvenile lamprey that would be handled during cleaning operations. Overall, adverse and beneficial effects on lamprey under the No-hatchery Alternative would likely be the same as those under the No-action Alternative.

There is no indication that hatchery programs under the No-action Alternative have contributed to the absence of cutthroat trout in the Sandy River Basin, so no increases in cutthroat trout abundance would be expected under the No-hatchery Alternative. However, cutthroat trout would be expected to continue to be handled during monitoring activities under the No-hatchery Alternative as part of the City of Portland HCP (NMFS 2008b).

Compared to the No-action Alternative, the abundance of whitefish and resident rainbow trout in the Sandy River Basin may increase because hatchery-produced salmon and steelhead cause adverse impacts through competition. Without such competition, whitefish and resident rainbow trout populations may increase. However, such population benefits are expected to be minor because resident rainbow trout and whitefish tend to be in the upper Sandy River Basin above the locations where hatchery juvenile salmon and steelhead are released. The abundance of resident rainbow trout would also be expected to increase if the natural population of winter steelhead increases under the No-hatchery Alternative, because anadromous steelhead could augment the resident rainbow trout population, by producing juvenile steelhead that residualize and then spawn with resident trout, though this augmentation would be expected to be minor. Factors affecting the abundance of resident and anadromous steelhead, such as instream habitat, food

availability, juvenile growth, and ocean conditions are not affected by the hatchery programs under the No-action Alternative and these factors would not change under the No-hatchery Alternative.

To the extent that the impacts from the current hatchery programs under the No-action Alternative are reducing the abundance of the natural salmon and steelhead in the basin, then predation on rainbow trout, whitefish, suckers, and sculpins would be expected to increase under the No-hatchery Alternative, though this increase would be minor, because predation by and competition with hatchery salmon and steelhead would be replaced by predation by and competition with natural-origin salmon and steelhead. The No-hatchery Alternative would not be expected to result in any changes in the abundances of the other non-listed species, which are not important prey for hatchery and natural-origin salmon and steelhead. To the extent that the impacts from the current hatchery programs under the No-action Alternative are reducing the abundance of the natural salmon and steelhead in the basin, then those species that prey on juvenile salmon and steelhead would be expected to see an increase or no change as natural production replaces hatchery juvenile salmon and steelhead releases that would be eliminated under the No-hatchery Alternative.

The non-ESA-listed fish found in the Sandy River Basin would be adversely impacted by fisheries that target these species as well as fisheries targeting returning hatchery adults (Subsection 3.4, Non-listed Fish). Impacts under the No-hatchery Alternative would not be expected to change substantially from current levels because fisheries that target the non-listed fish would continue to occur, though there would likely be some reduction in the level of fishery effort since fisheries targeting hatchery-origin fish from the Sandy River programs under the No-action Alternative would not occur. However, that reduction could also be offset by increases in fishery efforts on non-listed fish in the basin. Therefore, the overall change in fishery effort, likely in the form of a reduction in overall effort but somewhat higher effort on non-listed fish, would be of unknown but likely minor magnitude.

4.4.3. Alternative 3 (Reduced Production Alternative) – Production Limited to levels that would Achieve less-than-5 Percent pHOS Goal

Under the Reduced Production Alternative, the hatchery programs would affect non-listed fish in the Sandy River Basin in three ways: through obstruction or other behavioral effects of the structures required by the ongoing hatchery programs, through incidental impacts in fisheries targeting hatchery fish returning to the Sandy River Basin, and through ecological interactions.

The release of hatchery salmon and steelhead under the Reduced Production Alternative would be expected to have similar effects on non-listed fish in the Sandy River as under the No-action Alternative. However, adverse effects from competition and predation under the Reduced Production Alternative would be expected to be less than under the No-action Alternative because fewer hatchery salmon and steelhead would be released. As under the No-action Alternative, the release of hatchery salmon and steelhead would be expected to provide a minor benefit as prey the non-listed fish. Overall, the release of fewer hatchery salmon and steelhead in the Sandy River under the Reduced Production Alternative could result in minor adverse or beneficial effects on non-listed species. These effects from the release of hatchery smolts under

the Reduced Production Alternative would not occur under the No-hatchery Alternative because the hatchery programs would be terminated.

It is possible that lamprey in the Sandy River Basin might benefit from the additional salmon and steelhead hosts in the marine environment made available by hatchery fish, but this benefit would be smaller under the Reduced Production Alternative than under the No-action Alternative because fewer hatchery adults would be produced. Adverse or beneficial impacts would occur on lamprey at the Sandy Hatchery under the Reduced Production Alternative as under the No-action Alternative. Impacts from hatchery operations would be the same as described under the No-action Alternative.

The operation of the hatchery programs would not be expected to make recolonization or reintroduction of cutthroat trout any less likely under the Reduced Production Alternative. Impacts from the handling of cutthroat trout during monitoring activities would be expected to continue under the Reduced Production Alternative just as under the other alternatives. The impacts would be expected to be minor because of the small number of fish handled.

Under the Reduced Production Alternative, the adverse impacts related to competition on resident rainbow trout and whitefish in the action area would be reduced compared to the No-action Alternative because fewer hatchery fish would be released. The operation of the weirs would continue under the Reduced Production Alternative, and the effects would be expected to be the same as under the No-action Alternative and greater than under the No-hatchery Alternative. Impacts on rainbow trout and whitefish from the monitoring activities as described under the No-action Alternative would be the same since these activities would continue under the Reduced Production Alternative.

As under the No-action Alternative, other non-listed species in the action area would not be expected to be adversely impacted by the hatchery operations under the Reduced Production Alternative. Impacts on recreational fisheries would likely be the same as those described under the No-action Alternative.

4.4.4. Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule

Under the Proposed Action Alternative, the hatchery programs would affect non-listed fish in the Sandy River Basin in three ways: through obstruction or other behavioral effects of the structures required by the ongoing hatchery programs, through incidental impacts in fisheries targeting hatchery fish returning to the Sandy River Basin, and through ecological interactions.

The release of hatchery salmon and steelhead under the Proposed Action Alternative, as under the No-action Alternative and Reduced Production Alternative, would be expected to have either adverse or beneficial biological or ecological effects on non-listed fish in the Sandy River. The impact from competition under the Proposed Action Alternative would be expected to be somewhere larger than the Reduced Production Alternative and smaller than the No-action Alternative because the number of hatchery salmon and steelhead released would be intermediate to those two alternatives. The release of hatchery salmon and steelhead would be expected to provide a benefit by providing prey for the non-listed fish.

It is possible that lamprey in the Sandy River Basin might benefit from the additional salmon and steelhead hosts in the marine environment made available by hatchery fish under the No-action Alternative, but this benefit would be reduced under both the Proposed Action Alternative and the Reduced Production Alternative because fewer hatchery adults would be produced. Lamprey would be impacted either positively or negatively at the Sandy Hatchery under the Proposed Action Alternative as under the No-action Alternative. Impacts from hatchery operations would be the same as described under the No-action Alternative.

The operation of the hatchery programs under the Proposed Action Alternative would not expected to make recolonization or reintroduction of cutthroat trout any less likely than any of the other alternatives. Impacts from the handling of cutthroat trout during monitoring activities would be expected to continue under the Proposed Production Alternative just as under the other alternatives; similarly, impacts would be expected to be minor because of the small number of fish handled.

The abundance of resident rainbow trout, and whitefish in the Sandy River Basin would be affected under the No-action Alternative to the extent that hatchery salmon and steelhead produced are impacting these species through competition. Under the Proposed Action Alternative as with the Reduced Production Alternative this impact would be reduced because fewer hatchery fish would be released. The operation of weirs would continue under the Proposed Action Alternative, and the effects would be expected to be the same as under the No-action Alternative, but greater than under either the Reduced Production Alternative or the No-hatchery Alternative. Impacts on rainbow trout and whitefish from monitoring activities as described under the No-action Alternative would be the same since these activities would continue under the Proposed Action Alternative.

As under the No-action Alternative, other non-listed species in the action area would not be expected to be adversely impacted by hatchery operations under the Proposed Action Alternative.

Impacts on recreational fisheries would likely be the same as those described under the No-action Alternative, even though fewer hatchery fish would be expected to return under the Proposed Action Alternative because fewer hatchery fish would be released.

4.5. Effects on Instream Fish Habitat

All Alternatives

As described in the Subsection 3.5, Instream Fish Habitat, a number of key limiting factors were identified for Sandy River salmon and steelhead including reduced habitat quality, complexity, and connectivity with off-channel habitats (ODFW 2010a). Conversely, a number of habitat restoration actions have been completed and are ongoing that are designed to address these limiting factors and their causes in the Sandy River Basin. Under any alternative, both ongoing limiting factors and restoration activities are expected to continue. Limiting factors would continue to impair habitat quality, complexity, and connectivity; however, these adverse effects

would also continue to be mitigated through ongoing and planned restoration projects (Subsection 3.5, Instream Fish Habitat).

4.5.1. Alternative 1 (No-action) – Continue to Operate the Four Hatchery Programs as Described and Approved in the 2012 Biological Opinion

Under the No-action Alternative, the potential effects on instream fish habitat would be related to the annual installation of the temporary weirs. Under the No-action Alternative, weirs would be installed manually with limited manipulation of the channel, with the exception of the manual movement of small boulders/cobble along the base of the picket fence (Subsection 2.1.1, Sandy River Spring Chinook Salmon Program). These would be temporary weirs that would be operated during the summer during low-flow periods – any instream habitat alterations would be expected to be minor and temporary, and would be naturally corrected during the first high water flow event.

Impacts on instream habitat would also occur under the No-action Alternative because of the presence of the hatchery intake and a reduction in flows, which would potentially impede or slow migration. However, as discussed in Subsection 4.2, Effects on Water Quality and Water Quantity, water flow through the section of stream between the hatchery intake and the outfall would not be reduced to near zero as in the past; therefore, migratory access restrictions through this stream section would be transitory and of low effect.

4.5.2. Alternative 2 (No-hatchery) – Do Not Approve the HGMPs under Limit 5 of the 4(d) Rule

The lack of the hatchery programs under the No-hatchery Alternative would be expected to have a minor beneficial effect on fish passage in Cedar Creek through the removal of the adult weir and retention of water in Cedar Creek that would have been used in the hatchery under the No-action Alternative. Under the No-hatchery Alternative, the proposed weirs would not be installed, removing these sources of adverse impact on habitat connectivity and access.

4.5.3. Alternative 3 (Reduced Production Alternative) – Production Limited to levels that would Achieve less-than-5 Percent pHOS Goal

Under the Reduced Production Alternative, impacts on fish habitat would be the same as under the No-action Alternative because the weirs would be operated; therefore, weir-related impacts on the fish habitat would be the same as under the No-action Alternative. The weir at the Sandy Hatchery would also be operated to collect broodstock and to remove hatchery adults with similar impacts on habitat connectivity and access. The effects on stream flow in the bypass reach between the hatchery intake and the hatchery outfall would be the same because hatchery coho salmon would be reared at the Sandy Hatchery under either alternative.

4.5.4. Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule

Under the Proposed Action Alternative, impacts on fish habitat would be the same as under the No-action Alternative and the Reduced Production Alternative. The weir would be in place, and

would continue to act as a passage barrier to migrating adults fish in Cedar Creek. Adult salmonids would continue to be transported or passed above the weir. Effects on stream flow in the bypass reach between the hatchery intake and the hatchery outfall would be the same as under the No-action Alternative.

4.6. Effects on Wildlife

4.6.1. Alternative 1 (No-action) – Continue to Operate the Four Hatchery Programs as Described and Approved in the 2012 Biological Opinion

Under the No-action Alternative, the hatcheries would continue to release juvenile salmon and steelhead into the action area though at reduced levels compared to the past (Figure 5). This would reduce the number of fish available to wildlife that consume salmonid eggs, juveniles, adults, and carcasses. However, this release would continue to provide a minor benefit to wildlife that take advantage of this resource.

Under the No-action Alternative, adult hatchery spring Chinook salmon would continue to be removed at the weirs, reducing the number of hatchery spring Chinook salmon that would be available to wildlife. The proportion of hatchery coho salmon and steelhead on the spawning grounds would remain at their current low level, and may decline for coho salmon due to reductions in the level of coho smolts released. The reduction in adult spring Chinook salmon available to wildlife species would not be expected to adversely impact wildlife species because a substantial number of the hatchery spring Chinook salmon that would be collected (except for those used for broodstock, sold, or provided to food banks) would be returned to the action area as carcasses for nutrient enhancement, making them available to wildlife and the larger ecosystem. Furthermore, if the natural population of spring Chinook salmon recovers as a result of the improved management of adult hatchery fish, the abundance of these fish would be expected to increase as well, eventually replacing those spring Chinook salmon removed at the weirs.

The installation and operation of the weirs under the No-action Alternative to collect spring Chinook salmon broodstock and to remove hatchery adults might cause interactions with wildlife species, causing changes in migration and feeding behavior. The actual effect of these interactions would be minor because the weirs would be located on tributaries located in semi-rural habitat where human activity already occurs, the weirs would be temporary and would affect the wildlife species for a limited amount of time each year, and the weirs would only disturb small reaches of each of the tributaries. Impacts on northern spotted owls and wolverines, which are present in the Sandy River Basin, would be expected to be minor because these species are not found in the areas where the weirs and hatchery facilities would be operated.

Fisheries that target the fish produced by the No-action Alternative would reflect current impacts on wildlife and wildlife habitat in riparian areas adjacent to the streams where fisheries occur. The effect of the No-action Alternative on wildlife results from the presence and activity of anglers in riparian areas. Fisheries for other species would continue to occur in the action area. The addition of salmon and steelhead fisheries, as would occur under the No-action Alternative, would be expected to only increase the amount of fishing effort. While the fishing effort directed at salmon and steelhead is relatively large in the action area, the additional effect of this effort on

wildlife or wildlife habitat would be minor because these fisheries, and the associated use of access points and roads, would overlap with fisheries targeting other species. The overall effect would be expected to be low as other shore-based activities, such as hiking, camping, and wildlife viewing would continue to occur in conjunction with other, ongoing fishing activities.

4.6.2. Alternative 2 (No-hatchery) – Do Not Approve the HGMPs under Limit 5 of the 4(d) Rule

Because the hatchery releases would end, the No-hatchery Alternative would be expected to eliminate the number of hatchery juveniles and adults available to wildlife species in the Sandy River Basin, including eggs and carcasses. Because none of the wildlife species are thought to be wholly dependent on salmon and steelhead for survival, the effect, if any, of removing those food sources would be expected to be minor (Subsection 3.6, Wildlife). However, if the natural populations of salmon and steelhead recover as a result of the elimination of the hatchery programs, the reduction in hatchery fish would be replaced with natural-origin fish.

Under the No-hatchery Alternative, weirs would not be operated to collect broodstock and to remove hatchery spring Chinook salmon, or trap and remove adult hatchery fish at the Sandy Hatchery. This would be expected to eliminate any interactions with wildlife species at these locations. Northern spotted owls and wolverines, which are present in the Sandy River Basin, would possibly benefit from the cessation of activities near the current hatchery and weir locations but, because of their current low abundances and distribution, and the small proportional area of their potential ranges occupied by the hatchery and weir structures, any such effect would be minor.

Under the No-hatchery Alternative, it would be expected that because salmon and steelhead fisheries would not occur in the Sandy River, and none of the human activities associated with the fisheries targeting salmon and steelhead in the action area would occur. Under the No-hatchery Alternative, there would be no new construction of fishery access points, roads, permanent camping sites, or any long-lasting habitat alterations related to salmon and steelhead fisheries access. However, other fishing activities would continue in the riparian areas, essentially using the same roads and camping sites as under current conditions, so no substantial decrease, if any, in effects on wildlife from fishing activities would be expected under the No-hatchery Alternative.

Impacts on wildlife habitat from hiking, camping, wildlife viewing, and other shore-based activities would continue and may increase under the No-hatchery Alternative because these would be an alternative to fishing activities eliminated by the lack of hatchery programs in the Sandy River. Therefore, beneficial effects, if any, on important habitats for a variety of wildlife species would be minor under the No-hatchery Alternative.

4.6.3. Alternative 3 (Reduced Production Alternative) – Production Limited to Levels that would Achieve less-than-5 Percent pHOS Goal

Under the Reduced Production Alternative, hatcheries would continue to release juvenile salmon and steelhead into the action area though at reduced levels compared to the past (Table 2) and compared to the No-action Alternative. This would reduce the number of fish available to

wildlife that consume salmonid eggs, juveniles, adults, and carcasses. However, this release would continue to provide a minor benefit to wildlife that take advantage of this resource.

Impacts associated with weir operation under the Reduced Production Alternative would be the same as those described under the No-action Alternative. Furthermore, as under the No-action Alternative, if the natural population of spring Chinook salmon recovers as a result of the improved management of adult hatchery fish, the abundance of these fish would be expected to increase as well, eventually replacing those spring Chinook salmon removed at the weirs.

The installation and operation of weirs under the Reduced Production Alternative would result in the same effects as described under the No-action Alternative. Similarly, effects on northern spotted owls and wolverines would be the same as under the No-action Alternative.

Fisheries that target fish produced under the Reduced Production Alternative would reflect current impacts on wildlife and wildlife habitat in riparian areas adjacent to the streams where fisheries occur, similar to what would occur under the No-action Alternative. The effect of the Reduced Production Alternative on wildlife, wildlife habitat, and fisheries for non-salmonid species would also be the same as described under the No-action Alternative.

4.6.4. Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule

Under the Proposed Action Alternative, hatcheries would continue to release juvenile salmon and steelhead into the action area though at reduced levels compared to the past (Table 2) and compared to the No-action Alternative. However, the release would be more than under the Reduced Production Alternative or the No-hatchery Alternative. This would reduce the number of fish available to wildlife that consume salmonid eggs, juveniles, adults, and carcasses. However, the Proposed Action Alternative release would continue to provide a minor benefit to wildlife that take advantage of this resource.

Under the Proposed Action Alternative, adult hatchery spring Chinook salmon would continue to be removed at the weirs, reducing the number of hatchery spring Chinook salmon that would be available to wildlife. The proportion of hatchery coho salmon and steelhead on the spawning grounds would remain at their current low level, and may even decline due to reductions in the level of coho smolts released. The reduction in adult spring Chinook salmon available to wildlife species would not be expected to adversely impact wildlife species because all of the hatchery spring Chinook salmon that would be collected (except for those used for broodstock, sold, or provided to food banks) would be returned to the action area as carcasses for nutrient enhancement, thus making them available to wildlife and the larger ecosystem; however, the number of carcasses would be expected to be lower than under the No-action Alternative because fewer spring Chinook salmon would be released. Furthermore, as with the other alternatives, if the natural population of spring Chinook salmon recovers as a result of the improved management of adult hatchery fish, the abundance of these fish would be expected to increase as well, eventually replacing those spring Chinook salmon removed at the weirs.

Columbia white-tailed deer and the streaked horned lark are not found in the Sandy River Basin and thus would not be affected by the hatchery programs under the No-action Alternative.

Impacts associated with weir operation under the Proposed Action Alternative would be the same as those described under the No-action Alternative. Furthermore, as under the No-action Alternative, if the natural population of spring Chinook salmon recovers as a result of the improved management of adult hatchery fish, the abundance of these fish would be expected to increase as well, eventually replacing those spring Chinook salmon removed at the weirs.

Fisheries that target fish produced under the Proposed Action Alternative would reflect current impacts on wildlife and wildlife habitat in riparian areas adjacent to the streams where fisheries occur, similar to what would occur under the No-action Alternative. The effect of the Proposed Action Alternative on wildlife, wildlife habitat, and fisheries for non-salmonid species would also be the same as described under the No-action Alternative.

4.7. Effects on Socioeconomics

All Alternatives

The hatchery programs in the Sandy River Basin would not have any effect on wildlife in the action area that would be subject to hunting, so none of the alternatives considered here would differ in the potential benefit that might be derived from hunting, nor is hunting or wildlife management for hunting any part of the proposed action. As a result, the remainder of the analysis in this subsection focuses on freshwater fisheries.

Under any alternative, the hatchery programs in the Sandy River Basin would not be expected to affect Native American economics, cultural life, or subsistence because tribal activities in the basin are minimal, even though tribal hunting and fishing activities historically occurred in the Sandy River Basin. Northwest Native American tribes are not dependent on Sandy River hatchery salmon and steelhead; tribal fisheries for salmon and steelhead generally occur in the Columbia River upstream of the confluence with the Sandy River. Any potential effect on tribal members would be the same as those experienced by non-tribal members who fish recreationally in the action area.

4.7.1. Alternative 1 (No-action) – Continue to Operate the Four Hatchery Programs as Described and Approved in the 2012 Biological Opinion

The No-action Alternative would be expected to have beneficial impacts on socioeconomics in the action area. Such benefits would be realized by visitors continuing to support community expenditures for freshwater fisheries, including through the purchase of recreational supplies such as fishing gear, license fees, camping equipment, consumables and fuel at local businesses, and lodging expenditures. The cost of fishing licenses would not be expected to change, but the number of anglers fishing in the Sandy River Basin – and, therefore, the total revenue generated by purchase of fishing licenses – may possibly increase under the No-action Alternative if hatchery returns increase.

Dean Runyan Associates (2009) provides economic estimates for freshwater fisheries for the action area (Table 8). The No-action Alternative would likely contribute to the $20.5 million direct expenditures by freshwater anglers from the Portland Metropolitan Area (Subsection 3.7,

Socioeconomics). The economic benefits of other activities associated with the fisheries (e.g., travel, local recreation, equipment purchases) in the action area would also be expected to continue at current levels (Table 8).

Recreational fisheries expenditures for fish produced at Mitchell Act funded hatcheries were over $9.2 million with direct and secondary economic effect of $17.3 million, and contributed to an estimated 395 jobs (Subsection 3.7, Socioeconomics) (Wegge 2010). The proportion that can be attributed to the Sandy Hatchery programs within the action area is unknown, but the Sandy Hatchery programs are only four programs out of almost 40 large and small programs that were funded by the Mitchell Act in the Lower Columbia River (NMFS 2014b). Under the No-action Alternative, economic effects similar to these would be expected to continue. As a comparison, the potential reduction in these totals from the closure of the hatchery programs under the No-hatchery Alternative is unknown because funds currently going to support the Sandy Hatchery programs could be spent at other ODFW or Mitchell Act hatcheries in the Lower Columbia River region.

Dean Runyan Associates (2009) estimated that, within the three counties (Multnomah, Clackamas, and Washington), an estimated $40 million was spent on fishing and fishing-related travel. Fishermen in the Portland Metropolitan Area are not limited to rivers in the three counties and can fish in other parts of the state. It is not clear if the No-action Alternative would increase or maintain visitor and hatchery expenditures and their effect on the median income in the three counties in the action area. Median incomes would likely remain generally similar to those described by recent years' statistics, since the fisheries supported by the proposed hatchery programs considered under the No-action Alternative are similar to those taking place now and when the 2008 economic data were collected (Subsection 3.7, Socioeconomics).

The expected revenue to support fishery management and law enforcement activities would remain the same as current levels under the No-action Alternative as a result of an increase in purchases of fishing licenses. The Federal tax to support fisheries research, development, and public information actions would remain as current under the No-action Alternative.

Additional beneficial impacts could occur under the No-action Alternative in the employment sector that supports such tourism and recreational services or the government sector that employs recreational fishery-related staff. The No-action Alternative could have a positive impact on the important contribution to economic activity for the Sandy River Basin that result from fishing activities, particularly if natural-origin adult abundance levels increase for each population.

4.7.2. Alternative 2 (No-hatchery) – Do Not Approve the HGMPs under Limit 5 of the 4(d) Rule

The cessation of the proposed hatchery programs under the No-hatchery Alternative would have relatively substantial effects on socioeconomics in the action area because the lack of hatchery salmon and steelhead production would be expected to preclude recreational fishing opportunities for salmon and steelhead in the Sandy River Basin for Portland Metropolitan Area residents, resulting in a reduction of visitors to this basin engaging in recreational fishing. This reduction could also result in reduced expenditures for fishing and camping gear, gasoline and supplies, food, and lodging relative to the No-action Alternative.

It is not clear what effect this reduced expenditure may have on the median income in the three large metropolitan counties adjacent to and included in the action area as a whole when compared to the No-action Alternative, but a reduction in activities that use locally owned or operated businesses would be expected to have an adverse impact on the incomes of persons employed by those businesses. In the context of the $2.5 billion spent annually on hunting and fishing activities in Oregon (Subsection 3.7, Socioeconomics), such an effect would likely be minor, but the effect becomes larger when considered from the perspective of expenditures associated with the $20.5 million spent in the Portland Metropolitan Area on fishing activities. It is unknown how much of the $20.5 million in expenditures would be lost if the Sandy River salmon and steelhead fisheries are closed, but some reduction of that amount would occur as compared to the No-action Alternative.

Dean Runyan Associates (2009) provides economic estimates for freshwater fisheries in the action area (Table 8). In the absence of the hatchery programs under the No-hatchery Alternative and the resulting elimination of hatchery fish available for harvest, the potential reduction of direct expenditures by freshwater anglers would be some portion of the $40 million (fishing and fishing-related travel) currently expended in the three Metropolitan area counties, and that would be expended under the No-action Alternative (Table 8). While this proportion is unknown, it would not likely be a substantial proportion of the total expenditures, due to the fact that, while the Sandy River is an important fishing destination, it is not the only or most important fishery in the area, so fishing effort lost to the Sandy River would be expected to move, in some part, to other nearby areas. Therefore, some portion of the economic benefits of other tourism and recreational activities (e.g., travel, local recreation, equipment purchases) in the action area would continue to be realized as under the No-action Alternative. The economic benefit of travel, local recreation, and equipment purchases would be reduced somewhat from the approximately $40 million under the No-hatchery Alternative (Subsection 3.7, Socioeconomics).

In addition, hatchery-related expenditures (e.g., equipment, maintenance, feed, chemicals) under the No-action Alternative would be eliminated as well and might adversely impact some local businesses in the action area. Expenditures in the local economy for food, clothing, household items, and for services from the three full-time ODFW employees and their families who are residents at the hatchery would also be eliminated and negatively impact local businesses. These impacts would likely be minor in the Portland Metropolitan Area because businesses are not wholly dependent on the hatchery programs for income. Furthermore, the annual state funds of $265,000 currently spent on the proposed hatchery programs (Subsection 3.7, Socioeconomics) would likely be spent to support hatchery programs in other areas of Oregon and possibly in the Portland Metropolitan Area.

Table 9 provides estimates of the number of hatchery salmon and steelhead that have been harvested in the Sandy River in recent years. If recreational fisheries are precluded in the Sandy River, a potential loss of a harvest of 630 spring Chinook salmon, 3,593 coho salmon, 1,542 winter steelhead, and 680 summer steelhead would result as compared to the No-action Alternative. The harvest of these fish may provide supplemental nutritional resources for the residents of the Portland Metropolitan Area that otherwise would not be available without the fisheries in the Sandy River if they were unable to access hatchery salmon and steelhead outside

the Sandy River Basin. The actual socioeconomic impacts on the residents in the action area from the loss of these fish may not be as great in the Portland Metropolitan area because incomes in this area tend to be higher than state averages.

Under the No-hatchery Alternative, the cost of fishing licenses would not be expected to change relative to the No-action Alternative, but the number of anglers fishing in the action area would be reduced or eliminated; however, the impacts on those license holders would be minor because they could fish in basins outside the action area. The expected revenue from the sale of fishing licenses to support fishery management and law enforcement activities would be expected to decrease under the No-hatchery Alternative as compared to the No-action Alternative if there is a decrease in purchases of fishing licenses. The Federal tax to support fisheries research, development, and public information actions that results from the sale of fishing tackle could decrease as a result of a decrease of purchases of fishing gear compared under the No-action Alternative, but the decrease would not be substantial because other fisheries in Oregon that are not affected by the No-hatchery Alternative would continue to generate tax revenues.

Additional negative impacts could occur from the No-hatchery Alternative relative to the No-action Alternative in the employment sector that supports such tourism and recreational services or the government sector that employs recreational fishery-related staff, though these impacts would be limited to fishing-related businesses within the action area. Many of these businesses also support non-fishing recreational activities, which could minimize any potential business impact under the No-hatchery Alternative.

4.7.3. Alternative 3 (Reduced Production Alternative) – Production Limited to levels that would Achieve less-than-5 Percent pHOS Goal

The Reduced Production Alternative would be expected to have positive impacts on socioeconomics in the action area similar to the No-action Alternative. Under the Reduced Production Alternative, economic impacts similar to the No-action Alternative would be expected to continue, though at levels somewhat lower than would be expected under the No-action Alternative. The potential reduction in these totals from the closure of the hatchery programs under the No-hatchery Alternative is unknown because the funds currently going to support the Sandy Hatchery programs could be spent at other ODFW or Mitchell Act hatcheries in the Lower Columbia River region.

Compared to the No-action Alternative, it is not clear if the Reduced Production Alternative would decrease or maintain visitor and hatchery expenditures and their effect on the median income in the three counties in the action area; median incomes would likely remain generally similar to those described by recent years' statistics, though the fisheries supported by the proposed hatchery programs considered under the Reduced Production Alternative might be smaller than those under the No-action Alternative and when the 2008 economic data were collected because fewer fish would be released (Subsection 3.7, Socioeconomics).

The expected revenue to support fishery management and law enforcement activities would similar to, but possibly less, than current levels and the No-action Alternative under the Reduced Production Alternative as a result of a decrease in the purchases of fishing licenses due to the lower production levels reducing the number of hatchery adults produced. As under the No-

action Alternative, the Federal tax to support fisheries research, development, and public information actions would be expected to remain at current levels under the Reduced Production Alternative because fisheries outside the Sandy River would not be affected by the Reduced Production Alternative.

Additional beneficial impacts could occur under the Reduced Production Alternative though not to the level that would occur under the No-action Alternative in the employment sector that supports such tourism and recreational services or the government sector that employs recreational fishery-related staff. Like the No-action Alternative, the Reduced Production Alternative could have a positive impact on the important contribution to economic activity for the Sandy River Basin because it maintains fishing activities, particularly if natural-origin adult abundance levels increase for each population, which would not occur under the No-hatchery Alternative.

4.7.4. Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule

The Proposed Action Alternative would be expected to have positive impacts on socioeconomics in the action area similar to the No-action Alternative. Under the Proposed Action Alternative, economic impacts similar to the No-action Alternative and the Reduced Production Alternative would be expected to continue though not as high as would be expected under the No-action Alternative, and greater than under the Reduced Production Alternative. As a comparison, the potential reduction in these totals from the closure of the hatchery programs under the No-hatchery Alternative is unknown because the funds currently going to support the Sandy Hatchery programs could be spent at other ODFW or Mitchell Act hatcheries in the Lower Columbia River region.

It is not clear if the Proposed Action Alternative would decrease or maintain visitor and hatchery expenditures and their effect on the median income in the three counties in the action area. Median incomes would likely remain generally similar to those described by recent years' statistics, though the fisheries supported by the hatchery programs considered under the Proposed Action Alternative might be smaller than those under the No-action Alternative and when the 2008 economic data were collected because fewer fish would be released (Subsection 3.7, Socioeconomics).

The expected revenue to support fishery management and law enforcement activities would similar to, but possibly less, than current levels and the No-action Alternative, under the Proposed Action Alternative as a result of a decrease in the purchases of fishing licenses due to slightly the lower production levels reducing the number of hatchery adults available to the fisheries. Like the No-action Alternative and the Reduced Production Alternative, the Federal tax to support fisheries research, development, and public information actions would be expected to remain at current levels under the Proposed Action Alternative because fisheries outside the Sandy River would not be affected by the Proposed Action Alternative.

Additional beneficial impacts could occur under the Proposed Action Alternative – though not to the level that would occur under the No-action Alternative – in the employment sector that supports such tourism and recreational services or the government sector that employs

recreational fishery-related staff. As under the No-action Alternative and the Reduced Production Alternative, the Proposed Action Alternative could have a positive impact on the important contribution to economic activity for the Sandy River Basin because it maintains fishing activities, particularly if natural-origin adult abundance levels increase for each population, which would not occur under the No-hatchery Alternative.

4.8. Effects on Tourism and Recreation

4.8.1. Alternative 1 (No-action) – Continue to Operate the Four Hatchery Programs as Described and Approved in the 2012 Biological Opinion

Under the No-action Alternative, tourism and recreation benefits in the action area would be realized as a result of visitors continuing to support community expenditures for freshwater fisheries. The No-action Alternative would be expected to result in a continuation of the number of visitors to the action area engaging in various recreational opportunities (Subsection 3.8, Tourism and Recreation). The support of visitors to the action area would result in maintaining expenditures in the community for freshwater fisheries, including through the purchase of recreational supplies such as fishing gear, license fees, camping equipment, consumables and fuel at local businesses, and lodging expenditures (Subsection 4.7, Socioeconomics). These benefits would be in addition to those that would continue from other recreational activities in the action area under any alternative (e.g., hiking and camping, river rafting and kayaking, picnicking, swimming, mountain biking, and non-consumptive observation of wildlife and scenery) (Subsection 3.8, Tourism and Recreation).

Beneficial impacts could occur under the No-action Alternative with regards to the employment sector that supports such tourism and recreational services or the government sector that employs recreational fishery-related staff, if fishing activities and license sales increase.

4.8.2. Alternative 2 (No-hatchery) – Do Not Approve the HGMPs under Limit 5 of the 4(d) Rule

The potential effects of the No-hatchery Alternative on tourism and recreation would be low to moderately adverse, because, as mentioned in Subsection 4.7, Effects on Socioeconomics, the lack of hatchery-supported salmon and steelhead fisheries could result in fewer visitors to the action area who both fish and hunt, and who may spend financial resources on other tourist attractions while visiting (Subsection 3.7, Socioeconomics). This lack of visitor tourism for recreational opportunities could then result in reduced community expenditures for freshwater fisheries, including through the purchase of recreational supplies such as fishing gear, license fees, camping equipment, consumables and fuel at local businesses, and lodging expenditures (Subsection 4.7, Effects on Socioeconomics). However, other tourism and recreational activities in the action area (hiking and camping, river rafting and kayaking, picnicking, swimming, mountain biking, and non-consumptive observation of wildlife and scenery) would be available to Portland Metro Area residents and could possibly increase if the listed salmon and steelhead populations recover (Subsection 3.8, Tourism and Recreation). Dean Runyan Associates (2009) estimated that almost 2.2 million Oregon residents and non-residents participated in non-fishing related activities in Oregon. A reduction in the number of tourists and recreational activities that would be expected to result from the fisheries closures in the action area under the No-hatchery

Alternative would not be substantial and may be off-set by increases in participation in these other recreational activities.

Compared to the No-action Alternative, negative impacts could occur under the No-hatchery Alternative in the employment sector that supports such tourism and recreational services or the government sector that employs recreational fishery-related staff, though these impacts would largely be limited to fishing-related businesses within the action area. Many of these businesses also support non-fishing recreational activities, which could minimize any adverse business impact under the No-hatchery Alternative.

4.8.3. Alternative 3 (Reduced Production Alternative) – Production Limited to Levels that would Achieve less-than-5 Percent pHOS Goal

Tourism and recreation benefits in the action area would be still be expected under the Reduced Production Alternative, but potentially not at the same levels as under the No-action Alternative. Such benefits would be realized by visitors continuing to provide expenditures in the community for freshwater fisheries. The Reduced Production Alternative would be expected to result in a continuation of the number of visitors to the action area engaging in various recreational opportunities; the number of visitors might be slightly lower than under the No-action Alternative because the number of fishermen might be lower due to the fewer hatchery fish being released (Subsection 3.8, Tourism and Recreation). Similar to the No-action Alternative, recreational visitors to the action area would result in community expenditures for freshwater fisheries, including through the purchase of recreational supplies such as fishing gear, license fees, camping equipment, consumables, and fuel at local businesses, and lodging expenditures though reduced by some unknown, but likely small, amount from those under the No-action Alternative (Subsection 4.7, Effects on Socioeconomics). These benefits would be in addition to those that would continue from other recreational activities in the action area under all the alternatives (e.g., hiking and camping, river rafting and kayaking, picnicking, swimming, mountain biking, and non-consumptive observation of wildlife and scenery) (Subsection 3.8, Tourism and Recreation).

As under the No-action Alternative, beneficial impacts could occur under the Reduced Production Alternative with regards to the employment sector that supports such tourism and recreational services or the government sector that employs recreational fishery-related staff, if fishing activities and license sales increase. However, these impacts would be limited to fishing-related businesses within the action area. Many of these businesses also support non-fishing recreational activities, which may minimize any adverse business impact from the Reduced Production Alternative.

4.8.4. Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule

Tourism and recreation benefits would be expected in the action area under this alternative, but at levels slightly less than under the No-action Alternative and similar to the Reduced Production Alternative because hatchery releases under the Proposed Action Alternative would be less than those that would occur under the No-action Alternative. Such benefits would continue to be realized from visitors continuing to support community expenditures for freshwater fisheries.

The Proposed Action Alternative would be expected to result in a continuation of the number of visitors to the action area engaging in various recreational opportunities, though at levels possibly somewhat lower than under the No-action Alternative because the number of fishermen might be lower due to the fewer hatchery fish being released (Subsection 3.8, Tourism and Recreation). Similar to the Reduced Production Alternative, support for the slight reduction in the number of the visitors to the action area would result in community expenditures for freshwater fisheries, including through the purchase of recreational supplies such as fishing gear, license fees, camping equipment, consumables and fuel at local businesses, and lodging expenditures though not as high as the No-action Alternative (Subsection 4.7, Effects on Socioeconomics). These benefits would be in addition to those that would continue from other recreational activities in the action area under all the alternatives (e.g., hiking and camping, river rafting and kayaking, picnicking, swimming, mountain biking, and non-consumptive observation of wildlife and scenery) (Subsection 3.8, Tourism and Recreation).

As under the No-action Alternative and the Reduced Production Alternative, beneficial impacts could occur under the Proposed Action Alternative with regards to the employment sector that supports such tourism and recreational services or the government sector that employs recreational fishery-related staff, if fishing activities and license sales increase. However, these impacts would be limited to fishing-related businesses within the action area. Many of these businesses also support non-fishing recreation, which could minimize any adverse business impact under the Proposed Action Alternative.

4.9. Effects on Environmental Justice

4.9.1. Alternative 1 (No-action) – Continue to Operate the Four Hatchery Programs as Described and Approved in the 2012 Biological Opinion (No-action)

Impacts on environmental justice under the No-action Alternative would be expected to be low because the composition of the angling public in Oregon did not reflect participation by minority groups proportional to race composition in the Portland Metropolitan Area (USFWS 2011a)(Subsection 3.9, Environmental Justice). Fishing opportunities provided under the No-action Alternative would not be expected to proportionally benefit or adversely impact any one minority or low income population group over another (White, Hispanic, Asian, African-American, and Native American) in the action area (Subsection 3.9, Environmental Justice). The only proportion of the general population that would continue to be affected under this alternative would be that proportion of the population that is dependent on public transportation, which does not access a majority of the Sandy River Basin.

Benefits from fisheries in the Sandy River Basin would tend to accrue to all population sectors in proportion to their participation in fisheries (which may or may not be proportional to their representation in the overall population). Because fishing opportunities would positively benefit the overall tourism and recreation-based economic and employment segment in the action area, all population sectors would potentially benefit under the No-action Alternative.

4.9.2. Alternative 2 (No-hatchery) – Do Not Approve the HGMPs under Limit 5 of the 4(d) Rule

Because all the population sectors participate in fisheries, the loss of fishing opportunities that may result under the No-hatchery Alternative would not be expected to result in a disproportionately adverse impact on any minority or low income population group – any potential negative economic effect would be experienced by all groups (White, Hispanic, Asian, African-American, and Native American) in the action area unless they were unable to access hatchery salmon and steelhead in other areas (Subsection 3.9, Environmental Justice). That proportion of the population that is reliant solely or largely on public transportation are not able to access areas where most salmon and steelhead fishing opportunities occur and, thus, would not be expected to be impacted by elimination of fishing opportunities in the Sandy River. Adverse effects on environmental justice communities under the No-hatchery Alternative could potentially be greater than those under the action alternatives, though these differences would be minor.

4.9.3. Alternative 3 (Reduced Production Alternative) – Production Limited to Levels that would Achieve less-than-5 Percent pHOS Goal

As under the No-action Alternative, impacts on environmental justice under the Reduced Production Alternative would be low because the population sectors generally participate in fisheries in proportions similar to their representation in the general population. Fishing opportunities provided under the Reduced Production Alternative, though potentially smaller than under the No-action Alternative, would not proportionally benefit or adversely impact any one minority or low income population group over another (White, Hispanic, Asian, African-American, and Native American) in the action area (Subsection 3.9, Environmental Justice).

As under the No-action Alternative, benefits from fisheries in the Sandy River Basin would not necessarily tend to accrue to all population sectors in proportion to their participation in fisheries – to the extent that lower-income residents might be dependent on public transportation, the Sandy River Basin may not be as accessible as for the general population, and they would be proportionally less affected by reductions in hatchery programs that produce fewer fish for harvest. Because fishing opportunities would positively benefit the overall tourism and recreation-based economic and employment segment in the action area even at the reduced level of hatchery releases, all population sectors that participate in the fisheries would potentially benefit under the Reduced Production Alternative though likely at a level lower than under the No-action Alternative.

4.9.4. Alternative 4 (Proposed Action) – Approve the HGMPs under Limit 5 of the 4(d) Rule

As under the No-action Alternative and the Reduced Production Alternative, impacts on environmental justice under the Proposed Action Alternative would be low because all the population sectors generally participate in fisheries, though not necessarily in proportion to their representation in the general population. Fishing opportunities provided under the Proposed Action Alternative, though potentially smaller than under the No-action Alternative, would not proportionally benefit or adversely impact any one minority or low income population group

over another (White, Hispanic, Asian, African-American, and Native American) in the action area (Subsection 3.9, Environmental Justice).

As under the No-action Alternative and the Reduced Production Alternative, benefits from fisheries in the Sandy River Basin would tend to accrue to all population sectors in proportion to their participation in fisheries except for those area residents that are dependent on public transportation. Because fishing opportunities would positively benefit the overall tourism and recreation-based economic and employment segment in the action area, all population sectors would potentially benefit under the Proposed Action Alternative.

5. CUMULATIVE IMPACTS

5.1. Mitchell Act Final Environmental Impact Statement

NMFS completed a Final Environmental Impact Statement (FEIS) that will guide NMFS in the annual funding of Mitchell Act hatchery programs in the Columbia River Basin (NMFS 2014b)(Subsection 1.6, Relationship to Other Plans and Policies). The FEIS has been incorporated by reference into this EA. The FEIS not only evaluates Mitchell Act-funded hatchery programs, but all the hatchery programs within the Columbia River Basin, including the Sandy River hatchery programs. The FEIS evaluates likely effects of hatchery production on a broad species and multi-species scale (i.e., ESUs and DPSs) in the Columbia River Basin, while this EA specifically evaluates effects of the proposed Sandy River programs at a site-specific level of detail.

The draft EIS analyzing Mitchell Act funding included five alternatives (one no-action and four action alternatives) in the FEIS, NMFS formulated and evaluated a sixth alternative, the Preferred Alternative. [17] The FEIS also provides an updated analysis of the original five alternatives evaluated in the draft EIS. FEIS Alternative 4 is most similar to the Proposed Action Alternative in this EA (EA Alternative 4). Specifically, FEIS Alternative 4 assumes that the spring Chinook salmon program would be integrated, and the coho salmon and summer steelhead programs would be operated the same as under the EA Proposed Action Alternative except that the number of smolts produced is less for Proposed Action Alternative in this EA than that what was evaluated in FEIS Alternative 4 (500,000 versus 700,000 coho salmon smolts; 75,000 versus 160,000 summer steelhead smolts).

Under FEIS Alternative 4, the winter steelhead program would be operated as a segregated program similar to the No-action Alternative in this EA. Alternative 1 in the FEIS did evaluate an integrated winter steelhead program in the Sandy River Basin that is consistent with the Proposed Action Alternative in this EA.

The FEIS Preferred Alternative differs from the EA Proposed Action because the Preferred Alternative in the FEIS incorporated the Sandy River hatchery programs approved in the 2012 NMFS biological opinion (NMFS 2012b). The Proposed Action Alternative in this EA describes the hatchery programs as they were proposed in HGMPs submitted in 2013, which differ somewhat from the 2012 opinion.

[17] The Mitchell Act FEIS alternatives were structured differently than those in this EA. In the FEIS, NMFS utilized a No-action Alternative that assessed the impacts of status quo hatchery operations, and five alternatives formulated around different policy directions and how those may be applied across all hatcheries in the Columbia Basin to change environmental impacts. This structure allowed the FEIS to capture a wide range of levels of impacts resulting from hatchery operations. In subsequent NEPA documents such as this EA, which evaluate the specific suite of actions and effects associated with a single or small group of hatchery programs, NMFS attempts to more precisely describe those environmental impacts associated with specific HGMPs. The outcome is an analysis that differs from the FEIS in its approach and its level of detail, but the impacts of the Proposed Action in any subsequent NEPA document analyzing effects of hatchery programs within the Columbia River Basin, such as this EA, would be within the range of impacts assessed in the FEIS.

The Mitchell Act FEIS summarized the environmental consequences of Alternative 4 compared to the FEIS No-action Alternative (i.e., the baseline) and determined that for all the ESUs/DPSs within the Columbia River Basin, the FEIS Alternative 4 would:

- reduce juvenile releases by 15 percent
- increase the abundance of natural-origin spawners by 11 percent
- increase productivity in 15 out of the 17 ESUs/DPSs
- increase genetic diversity by 37 percent
- decrease the total harvest by 8 percent
- reduce ex-vessel value by 3 percent
- reduce total economic benefit to income by 4 percent
- reduce jobs by 5 percent
- decrease recreational expenditures by 8 percent
- reduce tribal fish harvest by 10 percent
- reduce tribal fishing revenue by 9 percent
- reduce the abundance of wildlife (i.e., birds, marine mammals, orcas)
- main water quality and quantity
- potentially decrease the use of chemicals and antibiotics

Under the Proposed Action Alternative in this EA, the annual release goal of juvenile hatchery fish would be 835,000 smolts. This release into the Sandy River represents 0.6 percent of the estimated 140,593,000 hatchery salmon and steelhead released annually into the Columbia River Basin under FEIS Alternative 1 and 0.7 percent under FEIS Alternative 4.

The Mitchell Act FEIS compared alternatives in the Sandy River that described hatchery programs as they were operated prior to 2010 (Alternative 1 through Alternative 5) and after 2010 (Alternative 6). Alternatives 1, 2, 4, and 6 coincide with the types of hatchery programs that were analyzed in this EA. For spring Chinook salmon, the FEIS modeling estimated that under Alternative 4 (Hatchery Programs Meet Stronger Performance Goal), 2,228 natural-origin spawners would, on average, return annually to the Sandy River Basin (Table 15). This compares to 2,252 under the FEIS Alternative 1 (No-action) and 2,380 under FEIS Alternative 2 (No-hatchery). The slight reduction in the number of natural-origin spawners between FEIS Alternative 1 and FEIS Alternative 4 is due to a 50 percent increase in the number of smolts being released and a slightly higher pHOS level (Table 15). Under the Proposed Action Alternative for this EA, the estimated abundance of natural-origin spawners would be similar to the abundance estimated for FEIS Alternative 4, if the spring Chinook salmon program in the EA reached the full production level of 300,000 smolts. Furthermore, it would be expected that the abundance of natural-origin spawners would be higher under the EA Proposed Action Alternative, with a beginning production level of 132,000 smolts, being somewhere between FEIS Alternative 1 and Alternative 2 (Table 15).

Table 15. Mitchel Act FEIS modeling results for the Sandy River spring Chinook salmon population under FEIS Alternatives 1, 2, 4, and 6.

Metric	Alternative 1	Alternative 2	Alternative 4	Alternative 6 (Preferred Alternative)
Natural-origin Spawners	2,252	2,380	2,228	1,446
Productivity	5.0	5.0	4.9	2.6
pHOS	0.07	0.01	0.09	0.15
Hatchery smolt release	207,755	0	300,606	300,606
Contribution to Harvest	556	0	810	872
Program Type	Integrated	No Program	Integrated	Segregated

For the coho salmon population in the Sandy River, FEIS Alternative 4 and Preferred Alternative were similar to the EA Proposed Action Alternative with pHOS levels at 4 percent. The estimated natural-origin spawner abundance for these two alternatives was around 8,085 adults, which was substantially lower than FEIS Alternative 2, with an estimated abundance of over 10,000 (Table 16). Under the EA Proposed Action Alternative, the number of hatchery smolts released would be considerably less than under FEIS Preferred Alternative at 300,000 smolts, an almost 60 percent reduction. The lower release levels, in combination with a pHOS of less than 5 percent, would be expected to increase the abundance of natural-origin spawners higher than either FEIS Alternative 4 or the FEIS Preferred Alternative though not reaching levels as modeled for FEIS Alternative 2.

Table 16. Mitchell Act FEIS modeling results for the Sandy River coho salmon population under Alternatives 1, 2, 4, and 6.

Metric	Alternative 1	Alternative 2	Alternative 4	Alternative 6 (Preferred Alternative)
Natural-origin Spawners	6,666	10,060	8,099	8,070
Productivity	3.0	5.0	3.9	3.7
pHOS	0.07	0.0	0.04	0.04
Hatchery smolt release	700,081	0	700,081	700,081
Contribution to Harvest	3,606	0	3,547	3,536
Program Type	Segregated	No Program	Segregated	Segregated

For the Sandy River winter steelhead program, FEIS Alternative 1is most consistent with the winter steelhead program under the EA Proposed Action Alternative. The other alternatives in the FEIS all assume that the winter steelhead program would be operated as a segregated program consistent with the No-action Alternative in this EA. The FEIS, when modeling the Sandy River winter steelhead population, included the effects on the natural-origin population from the release of hatchery summer steelhead smolts. The FEIS modeling estimated that the abundance of natural-origin spawners would, on average, reach 2,118 adults annually (Table 17).

This estimate assumes a pHOS of 4 percent, which is less than the pHOS goal for the winter steelhead program under the EA Proposed Action Alternative. The natural-origin spawner abundance is about 6 percent less than what was estimated for the FEIS No-hatchery Alternative, however the difference would be expected to be less than estimated because FEIS Alternative 1 assumes a hatchery summer steelhead program of 160,000 smolts, which is more than twice the level under the EA Proposed Action Alternative (75,000 smolts).

Table 17. Mitchell Act FEIS modeling for the Sandy River winter steelhead population under Alternatives 1, 2, 4, and 6.

Metric	Alternative 1	Alternative 2	Alternative 4	Alternative 6 (Preferred Alternative)
Natural-origin Spawners	2,118	2,272	1,757	1,799
Productivity	3.4	3.4	2.4	2.7
pHOS	0.04	0.0	0.04	0.04
Hatchery smolt release	159,875	0	160,015	160,015
Contribution to Harvest	1,031	0	1,032	1,032
Program Type	Integrated	No Program	Segregated	Segregated
Summer Steelhead release	160,170	0	160,170	160,170
Contribution to Harvest	7,345	0	7,345	7,345
Program Type	Segregated	No Program	Segregated	Segregated

In summary, a cross comparison of the Mitchell Act FEIS Preferred Alternative and the EA Proposed Action demonstrates that the Mitchell Act FEIS would likely overstate the expected cumulative effects on the human environment in the Sandy River Basin or larger, Columbia River Basin vicinity because the two alternative analyses were based on different HGMP assumptions (2012 versus 2013 HGMPs). Consequently, a more accurate estimation of cumulative effects in the Sandy River Basin as analyzed in the two NEPA reviews can be assessed by comparing results of the EA Proposed Action with FEIS Alternative 4. Under this comparative scenario, direct and indirect effects from the Sandy River Basin site-specific HGMP approval (see EA Subsection 4, Environmental Consequences) would be similar to or smaller than those anticipated under FEIS Alternative 4 for the wider Columbia River Basin, as described above. Consequently, cumulative effects on the human environment would be minor and consistent with, or smaller than, those effects as described in the FEIS.

5.2. Other Agency Programs, Plans, and Policies

In addition to hatchery management in the Columbia River Basin as analyzed in the Mitchell Act FEIS, other Federal, tribal, and state actions are expected to occur within the action area, in other Columbia River tributaries, and in the migration corridor between the Sandy River and the Pacific Ocean that would affect the fish populations considered under the Proposed Action. State fisheries would occur in other Oregon tributaries and in the mainstem Columbia River.

Land management and water-use decisions that affect these populations are made inside and outside the Sandy River Basin. There are overarching concerns and legal mandates for the recovery of listed salmon and steelhead populations in the Columbia River Basin; at the same time, there are social and cultural needs for sustainable fisheries and sustainable economic use of resources.

There are numerous initiatives by state, Federal, tribal, and private entities designed to restore salmon and steelhead populations, but it is not usually clear who those initiatives would be implemented by, when they would be implemented, or how effective they would be. In part, this is due to the reduced effectiveness of individually and separately implemented actions at the local scale. An exception to this uncertainty, then, would come as a result of a more broad-scale implementation of different actions across larger portions of the watersheds – such a broad-scale approach exists in several scenarios currently playing out in the Columbia River Basin. In large part, these actions are coordinated through or in association with Federal ESA recovery plans either already developed (e.g., (ODFW 2010a) or currently in development by NMFS. These plans are intended to provide a framework by which Federal, state, local, tribal, and private actions can be designed and implemented in a manner that would most effectively restore salmon and steelhead populations. For example, NMFS has reached an agreement with the City of Portland (NMFS 2008b)) that addresses listed fish species issues raised during the relicensing of the Bull Run River Water Supply projects. State initiatives include legislative measures to facilitate the recovery of listed species and their habitats, as well as the overall health of watersheds and ecosystems. Regional programs are being developed that designate priority watersheds and facilitate development of watershed Management Plans. All of these regional efforts are expected to help increase salmon and steelhead populations in the action area (and elsewhere in the region) because of compatible goals and objectives.

Cumulative impacts of NMFS' Proposed Action under the 4(d) Rule would be minor, if at all measurable. The operation of the Sandy Hatchery programs as described in the proposed HGMPs is designed to be consistent with recovery efforts and actions outlined in the Recovery Plan (ODFW 2010a). The proposed hatchery operations, if successful, are expected to contribute to the recovery of the natural-origin salmon and steelhead populations in the Sandy River by, for example, the removal of hatchery spring Chinook salmon at weirs to reduce the proportion of hatchery spring Chinook salmon spawning naturally to less than 10 percent of the naturally spawning population. Monitoring and evaluation activities under the Proposed Action in combination with other monitoring activities would determine if the proposed hatchery programs are consistent with the Recovery Plan goals for salmon and steelhead in the Sandy River.

5.3. Conservation Management under the ESA

The hatchery programs and associated fisheries that may impact listed salmon and steelhead within the action area would be managed based on the impacts on ESA-listed fish that are returning to the Sandy River and their associated ESUs and DPSs. If the cumulative effects of other hatchery programs, fisheries, pinniped predation on salmonids, ocean conditions or conservation efforts do not allow sufficient escapement of returning adult salmon and steelhead to the action area to meet recovery goals while providing for the operation of the proposed hatchery programs, adjustments to fisheries and to the hatchery production would be proposed.

If the cumulative effects of salmon management efforts fail to provide for recovery of listed species, then impacts due to the hatchery programs and fishing in the action area would be substantially diminished. If the abundances of natural-origin populations are not increased in the Sandy River, then the effects of the Reduced Production and No-hatchery Alternatives are likely to be the more adverse, to the extent that a productive hatchery program might be used to supplement natural populations in cases of extremely small returns. The cumulative adverse impacts of the Proposed Action on recovery actions are expected to be minor because of reporting and monitoring requirements that would ensure compatibility with recovery plans. Management of the hatchery programs and of fishing opportunity is only one element of a large suite of regulations and environmental factors that may influence the overall health of listed salmon and steelhead populations and their habitat. The proposed hatchery programs include the use of monitoring so that hatchery managers can respond to changes in the status of affected listed species. Monitoring and adaptive management would help ensure that the affected ESU and DPS are adequately protected and would help counter-balance any potential adverse cumulative impacts. Healthy and self-sustaining Sandy River salmon and steelhead populations would be an important component in long-term recovery of each of the affected species as a whole, and the proposed hatchery programs are designed to support this objective.

5.4. Climate Change

The action area – the Sandy River Basin – is located in the Pacific Northwest. The climate is changing in the Pacific Northwest due to human activities, and this is affecting hydrologic patterns and water temperatures. Regionally averaged air temperature rose about 1.5°F over the past century (with some areas experiencing increases up to 4°F) and is projected to increase another 3°F to 10°F during this century. Increases in winter precipitation and decreases in summer precipitation are projected by many climate models, although these projections are less certain than those for temperature (Karl et al. 2009).

Higher temperatures in the cool season (October through March) are likely to increase the percentage of precipitation falling as rain rather than snow, and to contribute to earlier snowmelt. The amount of snowpack measured on April 1, a key indicator of natural water storage available for the warm season, has already declined substantially throughout the region. The average decline in the Cascade Mountains, for example, was about 25 percent over the past 40 to 70 years, with most of this due to the 2.5°F increase in cool season temperatures over that period. Further declines in Northwest snowpack are likely due to additional warming this century, varying with latitude, elevation, and proximity to the coast. April 1 snowpack is likely to decline as much as 40 percent in the Cascades by the 2040s (Karl et al. 2009).

High and base stream flows are likely to change with warming. Increasing winter rainfall is likely to increase winter flooding in relatively warm watersheds on the west side of the Cascade Mountains. Earlier snowmelt, and increased evaporation and water loss from vegetation, would increase stream flows during the warm season (April through September). On the western slopes of the Cascade Mountains, reductions in warm season runoff of 30 percent or more are likely by mid-century. In some sensitive watersheds, both increased flood risk in winter and increased drought risk in summer are likely due to warming of the climate (Karl et al. 2009).

In areas where it snows, a warmer climate means major changes in the timing of runoff: increased stream flows during winter and early spring, and decreases in late spring, summer, and fall. Flow timing has shifted over the past 50 years, with the peak of spring runoff shifting from a few days earlier in some places to as much as 25 to 30 days earlier in others. This trend is likely to continue, with runoff shifting 20 to 40 days earlier within this century. Major shifts in the timing of runoff are not likely in areas dominated by rain rather than snow (ISAB 2007; Karl et al. 2009).

Fish habitat changes due to climate change are likely to create a variety of challenges for ESA-listed species of fish. Higher winter stream flows can scour streambeds, damaging spawning redds and washing away incubating eggs (Karl et al. 2009). Earlier peak stream flows could flush young salmon and steelhead from rivers to estuaries before they are physically mature enough for the transition, increasing a variety of stresses and the risk of predation (Karl et al. 2009). Lower summer stream flows and warmer water temperatures would degrade summer rearing conditions in many parts of the Pacific Northwest for a variety of salmon and steelhead species (Karl et al. 2009), and are likely to reduce the survival of steelhead fry in streams with incubation in early summer. Other likely effects include alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition and predation risk from warm-water, non-native species (ISAB 2007). The increased prevalence and virulence of diseases and parasites that tend to tend to flourish in warmer water would further stress salmon and steelhead (Karl et al. 2009). Overall, about one-third of the current habitat for the Pacific Northwest's coldwater fish may well no longer be suitable for them by the end of this century as key temperature thresholds are exceeded (Karl et al. 2009).

Climate change is also likely to affect conditions in the Pacific Ocean. Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances (Karl et al. 2009). It is likely that, as ocean conditions change, abundances of salmon and steelhead would continue to change accordingly, resulting in changes in abundance of adults returning to freshwater to spawn.

The Sandy River originates from glaciers on the southern slopes of Mount Hood; if climate change reduces the snow pack that feeds these glaciers, then summertime flows may be reduced to an extent that would reduce the suitable habitat for spring Chinook salmon, coho salmon, and steelhead yearling rearing, decreasing their abundance. Climate change may also contribute to weather events in the basin that can affect rainfall and subsequent river flows. For example, a record low rainfall was recorded in the summer of 2012, affecting migration and spawning (Zweifel 2013). This record low rainfall was followed by a record high water event at the end of September in 2013 (Alsbury 2013a; Lackey et al. 2013); such events illustrate the variability in the Sandy River Basin that would be expected to increase under climate change. Climate change would be expected to increase the frequency of major flood events that can scour redds (especially for fall Chinook salmon) and adversely impact salmon and steelhead spawning and rearing in the Zigzag River and the upper Sandy River. Lower summer flows due to a reduced winter snow pack may increase water temperatures that may lead to an increase in the abundance of non-native warm water species that can compete and prey on listed salmon and steelhead.

Warmer water temperatures may also increase the incidence of disease outbreaks and virulence in both the natural population and hatchery-produced juveniles.

The hatchery programs would not affect climate change under any alternative because they would not produce any source of greenhouse gas emissions. However, under all of the alternatives except the No-hatchery Alternative, fish would be transported between hatchery facilities by truck. Trucks used for this activity would be in compliance with State emission standards required for licensing. Emissions from this localized and infrequent activity would not be expected to contribute in any meaningful way to adverse greenhouse gases affecting the environment.

If climate change contributes to a substantial decline in the abundance of listed salmon and steelhead populations in the Sandy River through impacts on habitat and from changes in ocean conditions, it might become necessary to consider the proposed hatchery programs as "safety net" programs to maintain genetic resources. The proposed hatchery programs are somewhat protected from the possible increase in disease prevalence from warmer water temperatures because much of the rearing occurs outside the basin and the fish are tested prior to transfer to the Sandy Hatchery and before release to limit disease transmission to the natural-origin populations.

While climate change may well have impacts on the abundance and/or distribution of ESA-listed salmonids that are considered under the Proposed Action, the proposed hatchery management described in the HGMPs and the associated monitoring provide the ability to evaluate hatchery program impacts as abundances change, making appropriate adjustments feasible and timely.

Operation of the hatchery programs under any action alternative would not affect Pacific eulachon. It is anticipated that, under any of the alternatives, the limitations on eulachon recovery would continue to affect the species through habitat impacts from ongoing sources. These limitations could be pronounced as a result of climate change, but this cumulative effect would not be related to hatchery operations.

6. AGENCIES CONSULTED

National Marine Fisheries Service
Oregon Department of Fish and Wildlife
Confederated Tribes of the Warm Springs Reservation Oregon
Cowlitz Indian Tribe

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