Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Section 7(a)(2) Not Likely to Adversely Affect Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation

Sandy River Spring Chinook Salmon, Coho Salmon, Winter Steelhead, and Summer Steelhead Hatchery Programs.

NMFS Consultation Number: WCR-2014-300

Action Agencies: National Marine Fisheries Service
Program Operators: Oregon Department of Fish and Wildlife

Affected Species and Determinations:

ESA-Listed Species	Status	Is the Proposed Action Likely to Adversely Affect Species or Critical Habitat?	Is the Proposed Action Likely To Jeopardize the Species?	Is the Proposed Action Likely To Destroy or Adversely Modify Critical Habitat?
Lower Columbia River steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	No
Lower Columbia River Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Lower Columbia River Coho Salmon (*O. kisutch*)	Threatened	Yes	No	Not Designated
Columbia River Chum Salmon (*O. keta*)	Threatened	No	No	No
Southern Pacific Eulachon (Thaleichthys pacificus)	Threatened	No	No	No

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

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

Issued By:

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Date: Aug. 7, 2014

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1. INTRODUCTION

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

There are two proposed actions in this opinion: (1) NOAA's National Marine Fisheries Service's (NMFS) decision on a request submitted by the Oregon Department of Fish and Wildlife (ODFW) for ESA authorization under limit 5 of the 4(d) rule for four hatchery programs in the Sandy River basin (Table 1); and (2) future Mitchell Act funding for certain hatchery operations and maintenance[1]. This biological opinion does not predetermine the outcome of the 4(d) decision and only provides NMFS' opinion on the effects of the proposed action and whether it is likely to jeopardize listed species and/or adversely modify critical habitat. To the extent the ultimate 4(d) decision differs from that proposed and analyzed here, NMFS will reinitiate consultation. ODFW operates each of the programs and neither this opinion nor a proposed approval provides any authorization for those programs. The 4(d) rule exempts the take of salmon and steelhead listed as threatened species under the Endangered Species Act (ESA) if the entity follows a Hatchery and Genetics Management Plan (HGMP) that meets the 4(d) rule criteria and is approved by NMFS (July 10, 2000; 65 FR 42422, amended June 28, 2005, 70 FR 37160).

Table 1. Sandy River HGMPs and the action proponent.

Hatchery and Genetics Management Plan	Action Proponent
Sandy River spring Chinook salmon	ODFW
Sandy River coho salmon	ODFW
Sandy River winter steelhead	ODFW
Sandy River summer steelhead	ODFW

1.1. Background

This Biological Opinion (opinion) documents NMFS' ESA review of the HGMPs and its determination under limit 5 of the 4(d) rule. The opinion and incidental take statement portions of this document were prepared in accordance with section 7(b) of the ESA of 1973, as amended (16 U.S.C. 1531, *et seq*.), and implementing regulations at 50 CFR 402. With respect to designated critical habitat, the following analysis relied only on the statutory provisions of the ESA, and not on the regulatory definition of "destruction or adverse modification" at 50 CFR 402.02.

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

[1] In this opinion NMFS will refer to the "Proposed Action" as combining both of these two actions because NMFS does not expect that the effects of funding the hatchery operations will differ from the effects of the hatchery operations themselves.

The opinion, ITS, and EFH conservation recommendations are in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act") and underwent pre-dissemination review. The project files for both consultations are located at the Sustainable Fisheries Division (SFD) in Portland, Oregon.

1.2. Consultation History

The first hatchery consultations in the Columbia River Basin followed the first listings of Columbia River Basin salmon under the ESA. Snake River sockeye salmon were listed as an endangered species on November 20, 1991, Snake River spring/summer Chinook salmon and Snake River fall Chinook salmon were listed as threatened species on April 22, 1992, and the first hatchery consultation and opinion was completed on April 7, 1994 (NMFS 1994; 2008i). The 1994 opinion was superseded by "Endangered Species Act Section 7 Biological Opinion on 1995-1998 Hatchery Operations in the Columbia River Basin, Consultation Number 383" completed on April 5, 1995 (NMFS 1995). This opinion determined that hatchery actions jeopardize listed Snake River salmon and required implementation of reasonable and prudent alternatives (RPAs) to avoid jeopardy.

A new opinion was completed on March 29, 1999, after UCR steelhead were listed under the ESA (62 FR 43937, August 18, 1997) and following the expiration of the previous opinion on December 31, 1998 (NMFS 1999). That opinion concluded that Federal and non-Federal hatchery programs jeopardize Lower Columbia River (LCR) steelhead and Snake River steelhead protected under the ESA and described RPAs necessary to avoid jeopardy. Those measures and conditions included restricting the use of non-endemic steelhead for hatchery broodstock and limiting stray rates of non-endemic salmon and steelhead to less than 5% of the annual natural population in the receiving stream. Soon after, NMFS reinitiated consultation when LCR Chinook salmon, UCR spring Chinook salmon, Upper Willamette Chinook salmon, Upper Willamette steelhead, Columbia River chum salmon, and Middle Columbia steelhead were added to the list of endangered and threatened species (Smith 1999).

Between 1991 and the summer of 1999, the number of distinct groups of Columbia River Basin salmon and steelhead listed under the ESA increased from 3 to 12, and this prompted NMFS to reassess its approach to hatchery consultations. In July 1999, NMFS announced that it intended to conduct five consultations and issue five opinions "instead of writing one biological opinion on all hatchery programs in the Columbia River Basin." Opinions would be issued for hatchery programs in the, (1) Upper Willamette, (2) Middle Columbia River (MCR), (3) LCR, (4) Snake River, and (5) UCR, with the UCR NMFS' first priority (Smith 1999). Between August 2002 and October 2003, NMFS completed consultations under the ESA for approximately twenty hatchery programs in the UCR. For the MCR, NMFS completed a draft opinion and distributed it to hatchery operators and to funding agencies for review on January 4, 2001, but completion of consultation was put on hold pending several important basin-wide review and planning processes.

The increase in ESA listings during the mid to late 1990s triggered a period of investigation, planning, and reporting across multiple jurisdictions and this served to complicate, at least from a resources and scheduling standpoint, hatchery consultations. A review of Federal funded hatchery programs ordered by Congress was underway at the same time that the 2000 Federal

Columbia River Power System (FCRPS) opinion was issued by NMFS (NMFS 2000). The Northwest Power and Conservation Council (Council) was asked to develop a set of coordinated policies to guide the future use of artificial propagation, and Reasonable and Prudent Alternative (RPA) 169 of the FCRPS opinion called for the completion of NMFS-approved hatchery operating plans (i.e., HGMPs) by the end of 2003. The RPA required the Action Agencies to facilitate this process, first by assisting in the development of HGMPs, and then by helping to implement identified hatchery reforms (NMFS 2001). Also at this time, a new *U.S. v. Oregon* Columbia River Fisheries Management Plan (CRFMP), which included goals for hatchery management, was under negotiation and new information and science on the status and recovery goals for salmon and steelhead was emerging from Technical Recovery Teams (TRTs). Work on HGMPs under the FCRPS opinion was undertaken in cooperation with the Council's Artificial Production Review and Evaluation process, with CRFMP negotiations, and with ESA recovery planning (Jones 2002; Foster 2004). HGMPs were submitted to NMFS under RPA 169; however, many were incomplete and, therefore, were not found to be sufficient[2] for ESA consultation.

ESA consultations and an opinion were completed in 2007 for nine hatchery programs that produce a substantial proportion of the total number of salmon and steelhead released into the Columbia River annually. These programs are located in the LCR and MCR and are operated by the FWS and by the Washington Department of Fish and Wildlife (WDFW). NMFS' opinion (NMFS 2007a) determined that operation of the programs would not jeopardize salmon and steelhead protected under the ESA.

On May 5, 2008, NMFS published a Supplemental Comprehensive Analysis (SCA) (NMFS 2008i) and an opinion and RPAs for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia River Basin (NMFS 2008g). The SCA environmental baseline included the past effects of hatchery operations in the Columbia River Basin. Where hatchery consultations have expired or where hatchery operations have yet to undergo ESA Section 7 consultation, the effects of future operations cannot be included in the baseline." In some instances, effects are ongoing (e.g., returning adults from past hatchery practices) and included in this analysis.

Because it was aware of the scope and complexity of ESA consultations facing the co-managers and hatchery operators, NMFS offered substantial advice and guidance to help with the consultations. In September 2008, NMFS announced its intent to conduct a series of ESA consultations and that "from a scientific perspective, it is advisable to review all hatchery programs (i.e., Federal and non-Federal) in the UCR affecting ESA-listed salmon and steelhead concurrently" (Walton 2008). In November 2008, NMFS expressed again, the need for re-evaluation of UCR hatchery programs and provided a "framework for ensuring that these

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

hatchery programs are in compliance with the Federal Endangered Species Act" (Jones 2008). NMFS also "promised to share key considerations in analyzing HGMPs" and provided those materials to interested parties in February 2009 (Jones 2009).

Turning to the Sandy River hatchery programs, NMFS completed an opinion and ITS statement determining that the hatchery programs did not jeopardize ESA-listed species or adversely modify their critical habitat and furthermore concurred with ODFW that the HGMPs for four hatchery programs (ODFW 2011d; 2011c; 2011a; 2011b) satisfied the criteria under limit 5 of the 4(d) rule. The opinion and associated documents were signed September 28, 2012 (NMFS 2012b; 2012c). The programs approved in 2012 contained important changes to previous operations of the Sandy River programs, such as the relocation of spring Chinook salmon releases to an acclimation pond on the Bull Run River; the use of weirs to control the proportion of hatchery spring Chinook salmon in the upper basin and Bull Run River; the passage of natural-origin coho salmon and winter steelhead into Cedar Creek above the Sandy Hatchery; and reductions in release levels for spring Chinook salmon and coho salmon. ODFW began implementing these changes upon the approval of the 2011 HGMPs, and these changes are expected to result in substantial improvements in reducing the proportion of hatchery origin spawners (pHOS[3]) for spring Chinook salmon by 2015 and possibly sooner.

In the interest of making further improvements to the programs, ODFW submitted new HGMPs for each of the four programs to NMFS on August 1, 2013 (ODFW 2013f; 2013a; 2013d). The new HGMPs reflected substantial changes, in particular to the spring Chinook salmon, coho salmon, and winter steelhead hatchery programs. NMFS initiated ESA consultation (Jones 2013) and additional changes were called for following discussions with ODFW. ODFW submitted revised HGMPs to NMFS on October 29, 2013 and November 6, 2013 (ODFW 2013g; 2013e; 2013c; 2013b) and requested NMFS concurrence that the revised HGMPs satisfy the criteria under Limit 5 of the 4(d) rule. NMFS completed its preliminary review of the revised HGMPS and determined them sufficient for public review and comment contingent on ODFW confirming that NMFS has accurately characterized each proposed action and its effects on salmon and steelhead listed under the ESA (McIntosh 2013c). NMFS subsequently received ODFW confirmation (McIntosh 2013a). ODFW notified NMFS of a change regarding the deposition of unmarked summer steelhead collected at the weirs and requested that it be part of the Proposed Action (McIntosh 2014).

The HGMPs were made available for public comment upon publication of a notice of availability in the Federal Register on December 10, 2013 (December 10, 2013 78 FR 74116). The public comment period expired on January 9, 2014.

[3] In the Sandy River Basin, pHOS is estimated from data collected during spawning surveys. The abundance of the natural spawning population is estimated as well as 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 a purely a demographic metric. For genetic usage, pHOS has been inconsistently defined by the HSRG (see Section 2.4.1.2), but often as the *effective* proportion of natural spawners – i.e., the proportion of naturally spawning hatchery fish that contribute to the next generation, see Section 2.4.1.2 for a discussion.

1.3. Proposed Action

There are two distinct parts to the proposed action in this consultation: (1) NMFS' 4(d) determination on the HGMPs; and (2) future Mitchell Act funding for specific actions related to these HGMPs. In this section we describe: the proposed hatchery programs that are part of the "Proposed Action" using information provided in the HGMPs; and the funding of those programs through the Mitchell Act. "Action" means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 404.02). Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 404.02).

NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008g). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004). In this case, the Proposed Action is represented by the four HGMPs (ODFW 2013b) (Table 1) that propose to release spring Chinook salmon, coho salmon, winter steelhead, and summer steelhead into waters of the Sandy River Basin near Portland, Oregon. This opinion does not authorize the HGMPs but analyses the direct and indirect effects from the implementation of the Proposed Action on ESA-listed species and their critical habitat. Implementation of the four hatchery programs is included as a mitigation measure in the Federal Energy Regulatory Commission (FERC) license **(**Project No. 2821-000) issued to the City of Portland for the construction and for the continued operation of the dams in the Bull Run River, a tributary of the Sandy River. The City of Portland and the ODFW fund the hatchery programs and ODFW operates them.

The Mitchell Act became law in 1938 as Congress recognized that the salmon fishery in the Columbia River was in serious and progressive decline. Factors identified as leading to this decline were listed as habitat destruction and alteration due to deforestation, pollution, and water diversions. The Act authorized surveys and improvements in the Columbia River watershed for the benefit of salmon and other anadromous fish. The Act was amended in 1946 to provide for funding the use of facilities and services in the states of Idaho, Oregon, and Washington to develop the salmon resources of the region. ODFW previously received grant money pursuant to the Mitchell Act for partial funding of the Sandy Hatchery programs. Continued funding pursuant to these funding sources is part of the proposed action. 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. Funding for fiscal year 2014 will not be dispersed to ODFW until the consultation is completed.

Under limit 5 of the 4(d) rule, those hatchery programs, as described in the HGMPs, that have been evaluated and received concurrence that they meet the criteria in the limit may operate indefinitely into the future. However, under the limit 5, NMFS requires annual reporting on the operation of the HGMPs and the status of the ESA-listed populations affected by the HGMPs, as well as a comprehensive review every 5 years. If the HGMPs are not implemented as proposed or there is a change in circumstances, NMFS can reinitiate consultation on its concurrence that the HMGPs meet the 4(d) rule criteria based on information provided in the annual and 5-year

comprehensive reports. All of these actions are explicitly incorporated into this biological opinion and ITS. If they do not occur or are implemented differently than analyzed here, NMFS will reinitiate consultation in accordance with its regulation.

Approval of the 4 HGMPs would provide certainty to the operator and the region with regards to the operation of the hatchery programs in the Sandy River Basin and their potential effects on ESA-listed species. Approval will also ensure that the operation of the proposed hatchery programs will be closely monitored and the effects of the programs will be evaluated and routinely reported. An additional benefit is that the spring Chinook salmon, coho salmon, and winter steelhead programs will function as gene reserve in the event they are needed to reduce extinction risk for the natural populations in the Sandy River(NMFS 2005b).

The scientific basis and support for developing the proposed action comes from several different sources. Deliberations over the proposed action and the development of the corresponding HGMPs were timed to take advantage of several investigations that are particularly relevant to this situation, including the ESA Recovery Plan for LCR salmon and steelhead listed under the ESA (NMFS 2012b), the LCR Conservation & Recovery Plan for Oregon Populations of Salmon and Steelhead (Recovery Plan) (ODFW 2010), and a 2009 report by the Hatchery Science Review Group (HSRG)(HSRG 2009c). Each of these documents describes how hatchery programs in the Sandy River Basin can operate consistent with the conservation of listed salmon and steelhead. Other information cited in the HGMPs includes, the Native Fish Conservation Policy (ODFW 2003d), and the Fish Hatchery Management Policy (ODFW 2003a).

NMFS has identified several actions that are interrelated and/or interdependent with the proposed action. Monitoring of juvenile production in Cedar Creek above the Sandy Hatchery is interrelated and interdependent with the Proposed Action. Limited aspects of operation at the Clackamas Hatchery, Bonneville Hatchery Complex (Cascade Hatchery, Oxbow Hatchery), South Santiam Hatchery, and Oak Springs Hatchery are interrelated with the Proposed Action because fish from the four Sandy River hatchery programs are reared at these facilities before they are returned to the Sandy River Basin for acclimation and eventual release. These facilities are not interdependent on the Proposed Action because they support numerous hatchery programs and would operate whether or not fish from the Sandy River hatchery were reared there.

Fisheries are not part of the Propose Action and those fisheries that do occur in the Sandy River Basin are operated under an FMEP already authorized under the ESA (NMFS 2003c; 2008d).

1.3.1. Sandy River Spring Chinook Salmon Hatchery Program

The Sandy River spring Chinook salmon hatchery program is funded and operated to mitigate for habitat impacts and lost spring Chinook salmon production caused by the construction and operation of the City of Portland's Bull Run Project. Fish from the program are intended to be caught in recreational and commercial fisheries with strict limits on the number that escape the fisheries to spawn naturally.

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 spring Chinook salmon population. Broodstock for the new program was collected at Marmot Dam and the use of the non-endemic Clackamas spring Chinook salmon for broodstock was terminated (ODFW 2013b). Only un-marked spring Chinook salmon adults were used for broodstock for broodyears 2002 to 2007. In 2007, fewer 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. 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 Evolutionarily Significant Unit (ESU) (Jones 2011). From 2008 to 2010, up to 30% of the hatchery broodstock was comprised of natural-origin spring Chinook salmon, also known as the proportion of hatchery broodstock composed of natural-origin adults, or pNOB, with the remainder being made up of local-origin hatchery adults. In 2011, 2012, and 2013, the program used only local-origin integrated hatchery adults for broodstock, meaning pNOB was zero during this time. For the Proposed Action, in order to avoid substantial divergence between the hatchery and natural-origin spring Chinook salmon and reduce the threat of genetic effects, ODFW has proposed to effectively limit the proportion of hatchery fish that spawn naturally or pHOS to <10% and to achieve an annual pNOB of up to 20%. To produce up to 132,000 smolts for release, a total of 108 adults are needed for broodstock and out of this total, 22 would be natural-origin, the remainder will 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 need to be natural-origin adults. No more than 2% of the natural-origin spring Chinook salmon returning to the Sandy River Basin annually will be used for hatchery broodstock. The escapement of natural-origin spring Chinook salmon will be monitored at the weirs to ensure that the spring Chinook salmon escapement is such that broodstock collection will not exceed 2% of the natural-origin population. Under the Proposed Action, ODFW will 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 will be live spawned and then returned to natural spawning areas in the Sandy River where they can potentially spawn again.

The Proposed Action uses weirs to help control pHOS and collect broodstock for the hatchery program. 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 Proposed Action, broodstock for the spring Chinook salmon program will be collected from volitional returns to the Sandy Hatchery and from adults collected at temporary weirs in the Bull Run, Zigzag, and Salmon Rivers. The temporary weirs will be installed annually beginning in June and will 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. No changes to aquatic or riparian habitat would occur due to the installation of the weirs. The weirs will be used to trap

and remove all marked hatchery spring Chinook salmon to achieve the pHOS goal of <10% for the Sandy River Basin.

All natural-origin adults trapped will be enumerated and promptly passed upstream of the weirs except for a proportional number of natural-origin males needed to meet broodstock goals. The traps will be monitored at least daily, but more frequently during periods when larger numbers of spring Chinook salmon are expected to encounter the traps (late August/early September). Surveys will be regularly conducted immediately downstream of the weirs to understand how migrating spring Chinook salmon react to the weirs and to inform and guide decisions over the operation of the weirs considering the effects on ESA-listed species. ODFW has estimated that the maximum number of natural-origin spring Chinook salmon handled annually at the three weirs combined would be 3,080 natural-origin adults (Table 2). In addition, up to 50 natural-origin spring Chinook salmon could volunteer into the Sandy Hatchery and these fish will be returned unharmed to the Sandy River to spawn naturally (Table 2).

Adults collected for broodstock and all other hatchery adults would be removed from the system and transported to the Clackamas Hatchery or possibly 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 that benefits ESA-listed species. The broodstock would be held at the Clackamas Hatchery until spawning. Under the Proposed Action, after spawning, the green eggs would be taken to the 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 80 fish per pound (fpp). Spring Chinook salmon cannot be reared from eggs to smolts on station at the Sandy Hatchery due to facility and water limitations.

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. The juveniles would then be transported to the Bull Run Acclimation Pond where they would be acclimated for approximately 3 weeks before being released at approximately 10fpp. The maximum number of smolts that can be acclimated at one time in the Bull Run Acclimation pond is approximately 67,000, thus requiring two release groups to achieve a total release of 132,000 smolts. The first group is transferred in late February/early March, with the second group starting acclimation immediately after the first group is released. The juveniles are force released after the conclusion of the acclimation period, with the release precipitated by the removal of the standpipe from the pond causing the water level in the pond to drop. A crowder is used to move the smolts towards the water outlet pipe for release into the Bull Run River.

The number of spring Chinook salmon produced by the program and released into the Sandy River Basin has changed but more importantly, the basis for production decisions has fundamentally changed. In 2002, the production goal for hatchery spring Chinook salmon releases into the Sandy River Basin was reduced from 450,000 to 300,000 smolts. Under the Proposed Action, releases will begin at 132,000 fish annually and will only increase as long as

pHOS remains at or below 10%, based on a three-year moving average. This is an important change or shift best management practices – in this case ramping up production to not exceed an affects threshold for pHOS as opposed to exceeding the threshold while production ramps down. ODFW proposes to start production at 132,000 smolts, and based on annual monitoring and evaluation, increase releases incrementally, up to a maximum release goal of 300,000 smolts, so long as the three-year moving average for pHOS remains <10%. The <10% 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 2010), and incorporated into NMFS' LCR recovery plan ((NMFS 2013c). Under this management practice, the three-year moving average would never exceed pHOS would never exceed 10%. A three-year moving averaged is used because salmon and steelhead live under highly variable conditions (from freshwater to the ocean and back) and a single measure of snapshot in time does not provide the best indication of both the status of the fish and the factors that affect them. It also more protective of the natural populations, for example, the occasional pHOS that is >10% is preferable, from a gene-flow perspective, than annual pHOS estimates that push up against 10%.

The Sandy Hatchery is located at river mile (RM) 0.75 on Cedar Creek, a tributary to the Sandy River. The hatchery uses water from Cedar Creek, totaling up to 12,577 gallons per minute (gpm) under Oregon water permit number 23300. 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% 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) permit 10598. 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.

The Clackamas Hatchery is located at RM 22.6 of the Clackamas River in the Willamette River Basin and uses well water and water removed from the Clackamas River under permits issued by the state of Oregon (numbers S49433 and S42105). Screens are currently not compliant with NMFS screening criteria and alternate water sources are being investigated. Water from Clackamas hatchery is discharged into the Clackamas River under NPDES permit 102663.

The Oxbow Hatchery is located approximately 1 mile east of Cascade Locks, Oregon. The upper rearing ponds are supplied by gravity pipeline from Oxbow Springs located directly above the ponds. Salmon and steelhead do not use the springs so the pipeline is not screened. Water from the Oxbow hatchery is discharged in to Herman Creek under NPDES permit 64520.

Cascade Hatchery is located along Eagle Creek, 2.5 miles west of Cascade Locks, Oregon. Three water right permits for Cascade Hatchery total 20,205 gpm from Eagle Creek (Permit S-27519 – 10.0 cfs; S-24930 – 35.0 cfs; and S-2027 – 3.5 acre-feet). All raceways are supplied with single-pass water (i.e., water is not reused). The diversion on Eagle Creek is not screened in compliance

with NMFS criteria. Cascade Hatchery is currently under the NPDES permit 64435 with no effluent violations.

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. The temporary pond (10'-wide x 60'-long x 4'9"-high) 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 (450-600 gpm) is supplied by a 7.5-10 hp. pump with the intake screened to NMFS criteria (3/32" mesh w/spray wash cleaning system). The 6" intake pipeline carries water up to the pond (approximately 20 feet up from the river) and an 8" 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.

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 ~97%. All smolts released also receive an internal otolith mark that allows for identification of mis-marked hatchery reared fish. All spring Chinook smolts released in the Sandy Basin would also receive an internal coded wire tag (CWT) to further assist in identification.

1.3.2. Sandy River Coho Salmon Hatchery Program

The Sandy River coho salmon program is funded and operated to mitigate for habitat impacts and lost coho salmon production. Fish from the program are intended to be caught in recreational and commercial fisheries with strict limits on the number that escape the fisheries to spawn naturally. Continued funding for the program is expected under the Mitchell Act for fiscal year 2014. Mitchell Act funding for fiscal year 2015 and beyond is undecided, but for the purposes of this consultation it is assumed to continue indefinitely at historical levels. A Final Environmental Impact Statement providing guidance for the distribution of Mitchell Act funds will be released in time for decisions regarding the 2015 distribution of Mitchell Act funds.

From its inception in 1952-53 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 are no longer incorporated into the broodstock (i.e., pNOB is zero). Even so, hatchery coho have not substantially diverged, as yet, 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 (2003b) 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.

Because the coho salmon program does not intend to use local, natural-origin coho salmon for broodstock (pNOB = 0), ODFW has decided to impose a stricter pHOS goal in advance of any divergence between hatchery coho salmon and the natural population. The three-year moving average pHOS for hatchery coho salmon that escape the recreational and commercial fisheries will be not to exceed 5%. This is consistent with the Lower Columbia River Conservation and

Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010) and NMFS' LCR recovery plan (NMFS 2013c).

Broodstock for this program will be collected from returns to the Sandy Hatchery. The annual broodstock collection goal would be 250 adults (~150 females and ~100 males) for a 300,000 on-station release. 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 and allowed volitional passage into upper Cedar Creek to spawn naturally. ODFW estimates that up to 600 natural-origin coho salmon could be handled annually (Table 2). All hatchery fish that enter the hatchery trap are collected and are either selected for broodstock or are killed and then 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. Fish that may be in excess of broodstock and nutrient enrichment needs are provided to the Oregon Food Bank or local food banks.

The numerical goal for this coho program is to release 300,000 smolts annually. This level of release is a reduction from past programs (Figure 9). The coho salmon program production goal was 1,000,000 smolts in the early 1990s, 750,000 smolts through broodyear 2007, 500,000 smolts for broodyears 2008, 2009, and 2010 and 300,000 smolts starting with broodyear 2011 (ODFW 2013c).

Sandy River hatchery coho salmon are spawned, incubated, reared and released at the Sandy Hatchery. They are acclimated at the hatchery to return to the hatchery and reduce the number of hatchery coho salmon that spawn naturally. A detailed description of the Sandy Hatchery is provided in the previous section. Spawning generally begins in November and is completed by the end of the month. Smolts are released on station from the Sandy Hatchery into Cedar Creek at 15fpp, usually between mid-April and mid-May. Smolts are transferred 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 leave volitionally for a 24 hour period. After 24 hours water levels in the pond are gradually dropped further to promote emigration. After approximately 48 hours, water levels are dropped fully and any remaining fish enter Cedar Creek. Based on long-term observations, almost all coho smolts emigrate volitionally during the first 24 hour period after screen removal as this is because they are ready to leave freshwater for the ocean.

All (100%) of Sandy Hatchery coho salmon smolts are fin marked with an adipose fin-clip and a representative proportion of the smolts get a CWT. The fin-clipping will allow differentiation between natural and hatchery fish.

1.3.3. Sandy River Winter Steelhead Hatchery Program

The Sandy River winter 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 with strict limits on the number that escape the fisheries to spawn naturally. Continued funding for the program is expected under the Mitchell Act for fiscal year 2014. Mitchell Act for fiscal year 2015 and beyond is undecided, but for the purposes of this

consultation it is assumed to continue indefinitely at historical levels. A Final Environmental Impact Statement will be issued in 2014 and will guide decisions over the allocation of Mitchell Act funds beginning in fiscal year 2015.

This program was developed by using only naturally produced Sandy River winter steelhead in the hatchery brood from 2000-2002 (ODFW 2013g). 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 stock. The first release of hatchery smolts from the integrated Sandy River stock (stock 11) was in the spring of 2001 (ODFW 2013g). Integration with the local population was complete by 2004 when the annual broodstock collection goal shifted to include up to 30% natural-origin winter steelhead (pNOB of 30%) 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.

The Proposed Action intends to maintain the integration of the hatchery steelhead program and the Sandy River natural population. The Sandy River winter steelhead program is included in the LCR Steelhead DPS. The same analysis that is described above for the Sandy River hatchery coho salmon program was also completed for the winter steelhead program (NMFS 2003b; 2004b). These analyses showed that the 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). The program would include up to 26 natural-origin male winter steelhead in the broodstock annually (a pNOB of approximately 20%), and the number collected would be limited such than no more than 2% of the natural-origin adult winter steelhead returning to the Sandy River would be retained for broodstock. The escapement of natural-origin winter steelhead will be monitored during winter steelhead spawning surveys to ensure that the winter steelhead escapement is such that broodstock collection will not exceed 2% of the natural-origin population. The pHOS goal for hatchery winter steelhead that escape the recreational fisheries is 10% (based on a three-year moving average) and is consistent with the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010), and NMFS' LCR recovery plan (NMFS 2013c).

The hatchery program intends to annually release up to 160,000 acclimated smolts into Cedar Creek at the Sandy Hatchery (ODFW 2013g). For the program to release 160,000 smolts, it must collect 132 adult (66 pairs) of winter steelhead for broodstock, of which 26 would be Sandy River natural-origin winter steelhead males. The natural-origin males will be live spawned and then returned to natural spawning areas in the Sandy River where they can potentially spawn again. An adult weir on Cedar Creek would be used to direct all returning adult steelhead into adult holding ponds where they can be sorted. All unmarked steelhead (assumed to be natural-origin) are sampled and allowed volitional passage into upper Cedar Creek where the can spawn naturally. ODFW estimates that they may handle up to 200 natural-origin winter steelhead at the hatchery annually (Table 2). All hatchery winter steelhead surplus to broodstock needs at Sandy Hatchery are either recycled to the lower river for additional angling opportunities, 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.

Hatchery and natural-origin adults would be spawned and the resulting eggs incubated to the eyed-egg stage at the Sandy Hatchery. See description of the Sandy Hatchery above in section 1.3.1. Eyed eggs would be transferred to the Oak Springs Hatchery, hatched there, and then reared to 30fpp before being transferred to the Bonneville Hatchery in October. Oak Springs Hatchery is located at RM 47 on the Deschutes River and the water source is Oak Springs. The water rights at this facility provide for 53 cfs from 15 different certified points of the spring and no listed species are known to exist there. Hatchery effluent is managed to comply with conditions and water quality limits outlined in the existing NPDES permit 64515.

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 ~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 ~6fpp prior to transfer back to Sandy Hatchery for final acclimation and release into the Sandy River.

The fish are acclimated at the Sandy Hatchery for at least 3 weeks prior to release. 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, water levels are dropped fully and any remaining fish enter Cedar Creek. Based on long-term observations, approximately 80-90 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 hatchery by the end of the 48 hour period; usually less than 1,000 smolts remain after 48 hours.

This program does not intend that returning hatchery adults spawn naturally but returning hatchery adults should provide fishing opportunity and provide sufficient broodstock to perpetuate the hatchery program. Since this program is integrated, not divergent from the natural population of steelhead in the Sandy River, the pHOS goal for the program is less than 10%. Fish that return to the Sandy Hatchery from December through mid-February may be recycled once through the lower river fishery to provide additional angling opportunities. Recycled hatchery fish are released at Lewis and Clark Park (about RM 3). All recycled fish are distinctly marked (e.g. caudal punch or Floy tag) prior to release. Fish will only be recycled once; and all fish that are collected a second time will be permanently removed from the Sandy River by either 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 will be recycled to the lower river after February 16. Hatchery winter steelhead collected at the upper basin weirs/traps will not be recycled or returned to the river. All recycling will be discontinued if pHOS exceeds the 10%.

The pHOS goal (not to exceed 10%) applies to the Proposed Action because the hatchery fish are not intended to spawn naturally. This could change if the natural population declines. Hatchery winter steelhead in excess of broodstock needs may be passed upstream of Sandy Hatchery if ODFW determines and NMFS concurs that benefits to the natural population from hatchery supplementation outweigh the risks. ODFW will 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 will submit a proposal to NMFS for a supplementing the natural-origin population in Cedar Creek with returning hatchery winter steelhead.

1.3.4. Sandy River Summer Steelhead Hatchery Program

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. Continued funding for the program is expected under the Mitchell Act for fiscal year 2014. Mitchell Act funding for fiscal year 2015 and beyond is undecided, but for the purposes of this consultation it is assumed to continue indefinitely at historical levels. A Final Environmental Impact Statement will be issued in 2014 and will guide decisions over the allocation of Mitchell Act funds beginning in fiscal year 2015.

The Sandy River summer steelhead hatchery program proposes to sufficiently isolate hatchery summer steelhead from the winter steelhead natural population. The Sandy River does not have a natural population of summer steelhead. The hatchery program would use summer steelhead originating from the Washougal River in Washington State (Skamania stock) and released into the South Santiam River. Up to 35 females and 35 males would be collected for broodstock from hatchery adults returning to Foster Dam on the South Santiam River, at tributary to the Willamette River, Oregon. Spawning would be conducted at the South Santiam Hatchery from mid-December to the first week of February (ODFW 2013e). The operation of the South Santiam Hatchery summer steelhead program, including the broodstock collection and incubation of production for the Proposed Action, has been reviewed under Section 7 of the ESA (COE and NMFS 2008), and its relevant effects have therefore been included in the environmental baseline.

Eggs would be fertilized and incubation would start at the South Santiam Hatchery from January through March and then transferred to Bonneville Hatchery for final incubation and rearing. Summer steelhead are reared at Bonneville Hatchery for 13-14 months to a size of approximately 4.5fpp, before being transferred to the Sandy Hatchery for final acclimation and release. All (100%) of Sandy Hatchery summer steelhead smolts are adipose fin marked at Bonneville Hatchery to assure their identification as hatchery fish.

The hatchery program would acclimate and release up to 75,000 smolts into Cedar Creek at the Sandy Hatchery (ODFW 2013e). 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 80-90 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 for this program must not exceed 5% (based on a three-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 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 will be removed from the Sandy River. Unmarked summer steelhead collected at the tributary weirs/traps will be genetically sampled and released downstream of weirs. Unmarked summer steelhead collected at the upper basin weirs will be transported and released in the lower Sandy River (Lewis and Clark Park) and unmarked summer steelhead collected at the Bull Run weir will be released into the lower Sandy River. 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/or burying.

1.3.5. Monitoring, Evaluation, and Research

ODFW proposes to conduct monitoring, evaluation, and research (ME&R) activities in the Sandy River Basin to monitor performance indicators as described in the HGMPs (ODFW 2013g; 2013c; 2013b; 2013e). ODFW will provide annual ME&R plans for NMFS concurrence in advance of each upcoming year's activities.

Spawning ground surveys will be conducted throughout the Sandy River Basin, downstream and upstream of the Sandy Hatchery, to monitor pHOS, including the timing and spatial distribution of naturally spawning hatchery fish, the abundance of natural-origin fish, and the distribution of natural-origin spawners. These will be conducted annually for spring Chinook salmon, coho salmon, and winter steelhead. ODFW will use the data from the spawning ground surveys to annually estimate pHOS, and NMFS will in turn review the raw data and estimates of pHOS to

determine whether the pHOS goal (based on the three-year moving average) has been exceeded for each hatchery program.

Spring Chinook salmon spawning surveys and surveys of the spatial and temporal distribution of the fish below the weirs will also be used to evaluate whether and to what extent natural-origin spring Chinook salmon survival and spatial distribution are affected by operation of the weirs in the Salmon and Zigzag rivers. ODFW will annually monitor steelhead and coho salmon natural re-colonization of Cedar Creek. Up to 3,500 natural-origin steelhead smolts, and 5,000 natural-origin coho salmon smolts would be handled annually as a result of monitoring activities (Table 2).

To confirm that hatchery smolts released from the Sandy Hatchery and Bull Run acclimation pond are promptly leaving the Sandy River Basin for the Pacific Ocean, 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 (Table 2).

Table 2. Natural-origin adult and juvenile Spring Chinook salmon, coho salmon, and steelhead annually encountered, sampled/tagged, and retained for broodstock as the result of activities under the Proposed Action.

	Natural-origin Adult Salmonids					Natural-origin Juveniles			
Activity	Species	Encountered	Sampled	Broodstock	Mortality	Encountered	Sampled	Tagged	Mortality
Tributary Weir Operations									
	Spring Chinook Salmon	3,080	20[1]	22[2]	<5				
	Coho Salmon	50			<2				
	Steelhead	200	200[3]		<5				
Sandy Hatchery Adult Trap									
	Steelhead	200			<4				
	Coho Salmon	600	600		<12				
Steelhead Broodstock				26[4]	<5				
Rotary Screw Traps									
	Steelhead					3,500	500	500	<35
	Coho Salmon					5,000	200	200	<50
Juvenile Outmigration Sampling[5]									
	Chinook Salmon					1,000			<30
	Coho Salmon					1,000			<30
	Steelhead					100			<3

1. Spring Chinook salmon adults only sampled at the Bull Run weir to evaluate origin.
2. Natural-origin broodstock could increase to up to 42 adult males (< 10 mortalities) if the program release increases to 300,000.
3. ODFW will sample unmarked summer steelhead encountered at the Bull Run weir.
4. Natural-origin adult steelhead will be collected using hook and line.
5. Juveniles sampled are primarily fry and young of the year.

1.4. Action Area

In this section we describe where the proposed hatchery programs would most likely interact with ESA-listed species, this is called the Action Area. The "Action Area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area resulting from this analysis includes tributaries of the Sandy River accessible to anadromous fish and reaches of the Sandy River itself accessible to anadromous fish and downstream to its confluence with the Columbia River. ESA-listed species in the watershed that may be adversely affected include LCR Chinook salmon, LCR coho salmon, and LCR steelhead (Table 3).

The operation of hatchery facilities has the potential to affect ESA-listed salmon and steelhead in streams adjacent to hatchery facilities through the diversion of surface water or the maintenance of instream structures (e.g., the water intake and discharge structures) and the release of effluent. Under the Proposed Action, a number of hatchery facilities will be used, depending on the program, to spawn, incubate, and rear salmon and steelhead for the Sandy Hatchery programs.

- Sandy Hatchery
- Bull Run Acclimation Pond
- Clackamas Hatchery
- Oxbow Hatchery
- Cascade Hatchery
- Oak Springs Hatchery
- Bonneville Hatchery

The action area includes these facilities and portions of the adjacent streams where water withdrawals are affecting ESA-listed fish.

NMFS considered whether the mainstem Columbia River, the estuary, and the ocean should be included in the action area but the effects analysis was unable to detect or measure effects of the proposed action beyond the area described above, based on best available scientific information (AMIP 2009). Available knowledge and techniques 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[4]. From the scientific literature, the general conclusion is that the influence of density dependent interactions on growth and survival is likely immeasurably small. 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. NMFS will monitor emerging science and information and will reinitiate Section 7 consultation in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

[4] NMFS determined that the proposed hatchery programs would have no effect on southern resident killer whales or Steller sea lions and so did not extend the Action Area beyond the Sandy River Basin. This is because the hatchery fish produced from the programs would represent a very small proportion of the salmonids that could serve as prey for these species.

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

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon (*Oncorhynchus tshawytscha*)			
Lower Columbia River Chinook Salmon	6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Coho Salmon (*Oncorhynchus kisutch*)			
Lower Columbia River Coho Salmon	6/28/05; 70 FR 37160		6/28/05; 70 FR 37160
Steelhead (*Oncorhynchus mykiss*)			
Lower Columbia River Steelhead	1/05/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160

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

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

2.1. Introduction to the Biological Opinion

In this section we describe all of the parts of the biological opinion used to determine if the proposed action is likely to jeopardize ESA-listed species. Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts on the conservation value of the designated critical habitat.

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

This opinion uses the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[5] It does not rely on the regulatory definition of 'destruction or adverse modification' of critical habitat at 50 CFR. 402.02. NMFS will use the following approach to assess the effects of the Proposed Action described in Section 1.3.

Range-wide status of the species and critical habitat

This section describes the status of the species and critical habitat that are the subject of this opinion. The status review starts with a description of the general life history characteristics and the population structure of the ESU/DPS, including the strata or major population groups (MPG) where they occur. NMFS has developed specific guidance for analyzing the status of salmon and steelhead populations in a "viable salmonid populations" (VSP) paper (McElhany et al. 2000). The VSP approach considers four attributes, the abundance, productivity, spatial structure, and diversity of each population (natural-origin fish only), as part of the overall review of a species' status. For salmon and steelhead protected under the ESA, the VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" (50 CFR 402.02). In describing the range-wide status of listed species, NMFS reviews available information on the VSP parameters including abundance, productivity trends (information on trends, supplements the assessment of abundance and productivity parameters), spatial structure and diversity. We also summarize available estimates of extinction risk that are used to characterize the viability of the populations and ESU/DPS, and the limiting factors and threats. To source this information, NMFS relies on viability assessments and criteria in technical recovery team documents, ESA Status Review updates, and recovery plans. We determine the status of critical habitat by examining its physical and biological features (also called "primary constituent elements" or PCEs). Status of the species and critical habitat are discussed in Section 2.2.

Describe the environmental baseline

The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area* [6] on ESA-listed species. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early Section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 2.3 of this opinion.

Cumulative effects

Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably

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

[6] The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early ESA Section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

certain to occur within the action area[7]. Future Federal actions that are unrelated to the proposed action are not considered because they require separate Section 7 consultation. Cumulative effects are considered in Section 2.5 of this opinion.

Integration and synthesis

Integration and synthesis occurs in Section 2.6 of this opinion. In this step, NMFS adds the effects of the Proposed Action (Section 2.4) to the status of ESA protected populations in the Action Area under the environmental baseline (Section 2.3) and to cumulative effects (Section 2.5). Impacts on individuals within the affected populations are analyzed to determine their effects on the VSP parameters for the affected populations, and these are combined with the overall status of the strata/MGP to determine the effects on the ESA-listed species (ESU/DPS) which will be used to formulate the agency's opinion as to whether the hatchery action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat.

Jeopardy and adverse modification

Based on the Integration and Synthesis analysis in Section 2.6, the opinion determines whether the proposed action is likely to jeopardize ESA protected species or destroy or adversely modify designated critical habitat in Section 2.7.

Reasonable and prudent alternative(s) to the proposed action

If NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a RPA or RPAs to the proposed action.

NMFS also considered the potential effects of the proposed action on Columbia River Chum Salmon (*O. keta*) ESU and the Southern Pacific eulachon (*Thaleichthys pacificus*) DPS and determined that the proposed action was not likely to adversely affect either of these species or their designated critical habitat, as described in Section 2.11.

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

In this section we describe the ESA-listed species and their designated critical habitat. Using information provided in species status reviews and other reports we describe the status of the ESA-listed species and then focus on the status of those populations that are found in the Action Area. This opinion examines the status of each species (as defined below) that would be affected by the proposed action. The status is the level of risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the

[7] Cumulative effects" are those effects of future state or private activities, not involving Federal activities that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02).

condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value.

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

Within an ESU or DPS, 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 1 shows 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.

NMFS (2013c) in their LCR Recovery Plan identified what is necessary for a viable ESU/DPS:

- 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% 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 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 of catastrophic events.

- Viable populations should meet specific criteria for abundance, productivity, spatial structure, and diversity.

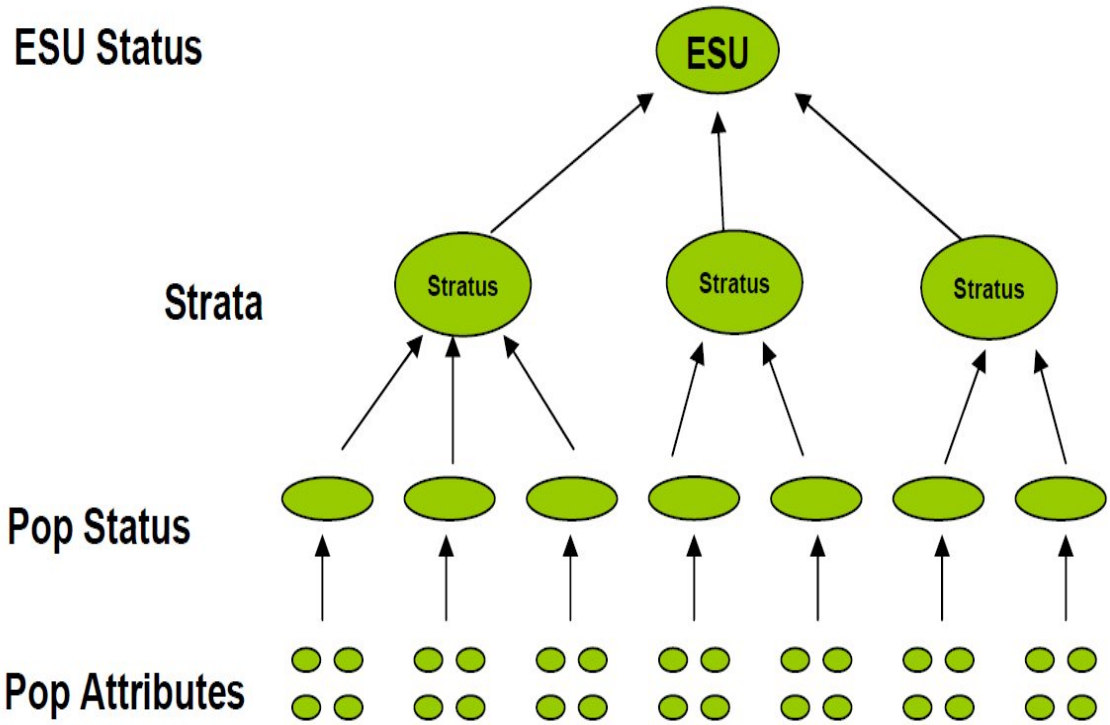

Figure 1. Hierarchical approach for ESU/DPS viability criteria.

2.2.1. Status of Listed Species

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (Pop Attributes in Figure 1)(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.

"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. McElhany et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends fundamentally on 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).

For species with multiple populations, once the biological status of a species' populations has been determined, NMFS assesses the status of the entire species using criteria for groups of populations (strata), as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread, to avoid concurrent extinctions from mass catastrophes, and spatially close, to allow functioning as metapopulations (McElhany et al. 2000).

2.2.1.1. Life History and Status of LCR Chinook Salmon

The Sandy River spring Chinook salmon population is part of the LCR Chinook Salmon ESU. The LCR Chinook Salmon ESU was first listed as threatened under the ESA in 1999 (64 FR 14308), and their threatened status was reconfirmed in 2005 (Table 3). 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 2 and Figure 3) and estimated that of these populations, 8-10 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 2 and Figure 3). 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 2003b). The ESU does not include spring Chinook salmon populations in the Clackamas River or the introduced Carson National Fish Hatchery spring Chinook salmon stock. Tule fall Chinook salmon in the Wind and Little White Salmon Rivers are included in this ESU, but not the introduced upriver bright fall Chinook salmon in the Wind and White Salmon Rivers and those spawning naturally below Bonneville Dam (Myers et al. 1998). 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 2003b; 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 (2003b), NMFS (2004b), and Jones (2011) and therefore NMFS considers the hatchery program to be integrated with the natural population.

Chinook salmon exhibit a wide variety of life history patterns that include variations in: age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: “stream-type” and “ocean-type” (Healey 1991; Myers et al. 1998). There are three different forms of Chinook salmon included in the LCR ESU: spring-run, early-fall “tules” and late fall “brights”. Spring-run Chinook salmon are a stream-type life history. Spring Chinook salmon ocean distribution is far from the coast (Healey 1983; 1991). These fish return to freshwater as adults in March and April, well in advance of spawning in August and September (Fulton 1968; Healey 1991). Spring Chinook salmon tend to spawn in the upper most reaches of tributary streams. 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 et al. 1993). The tule and bright fall Chinook salmon exhibit an ocean-type life history and northerly ocean migration patterns, with bright fish tending to travel farther north than the tule Chinook salmon. Tule fall Chinook salmon enter the Columbia River in August, rapidly moving into LCR 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 as late as the following March. All LCR Chinook salmon mature at two to six years of age, primarily returning as three- and four-year-old adults (Myers et al. 1998).

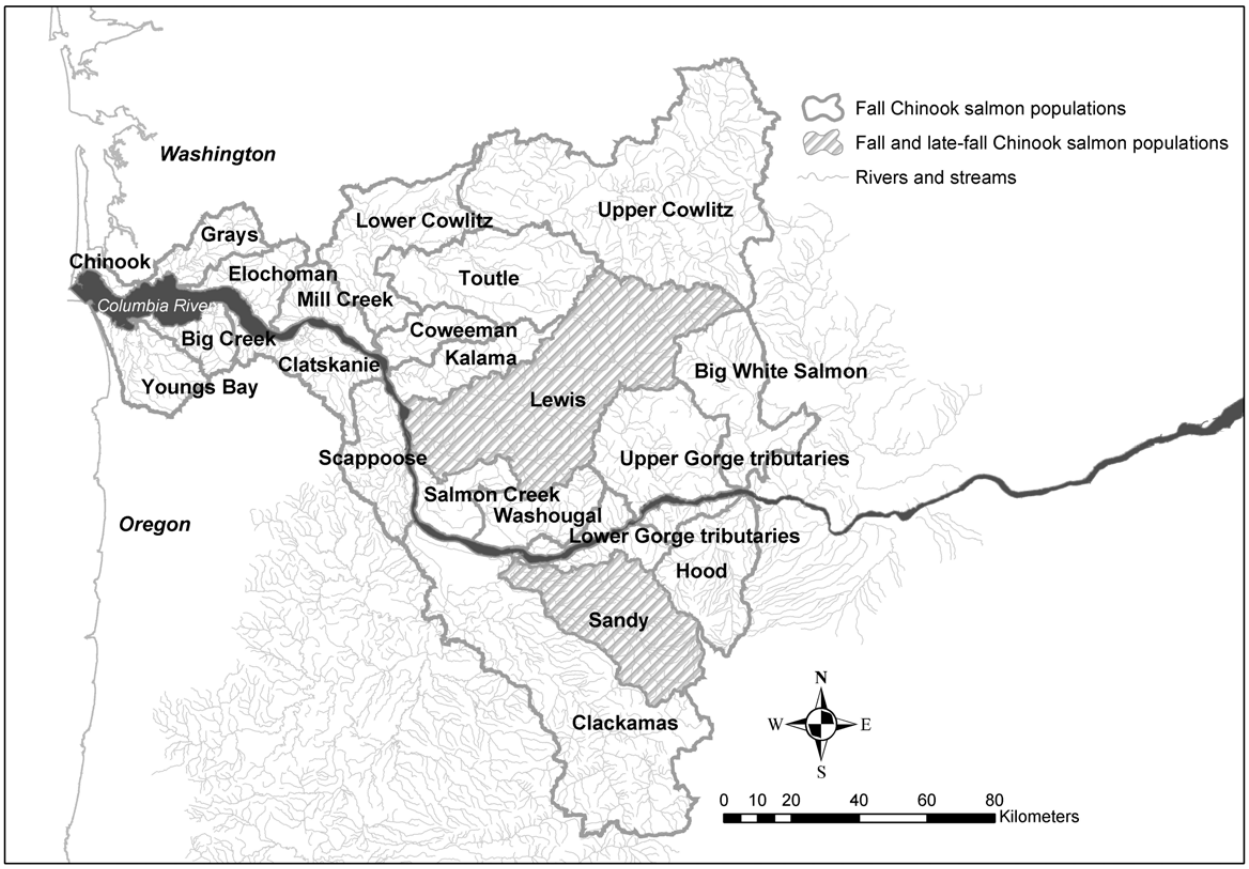

Figure 2. Historical independent LCR early and late fall Chinook salmon populations (Myers et al. 2006).

Spring Chinook salmon were present historically in the Sandy, Clackamas[8], Cowlitz, Kalama, Hood, White Salmon and Lewis Rivers. The Sandy, Cowlitz, Kalama, and Lewis populations are all in the Cascade spring Chinook Salmon strata, whereas the White Salmon and Hood are in the Gorge strata. Spawning and juvenile rearing areas have been eliminated or greatly reduced, primarily by dam construction. Dam construction substantially reduced the range of spring Chinook salmon in the Cowlitz and Sandy Rivers (Myers et al. 1998). Spring Chinook were extirpated in the White Salmon River after the completion of Condit Dam in 1917. They were extirpated in the Lewis River after the completion of Merwin Dam in 1931. In the Hood River, spring Chinook were extirpated in the 1960s following the breaching of a glacial dam and reintroduction efforts are underway there using spring Chinook salmon from the Deschutes River.

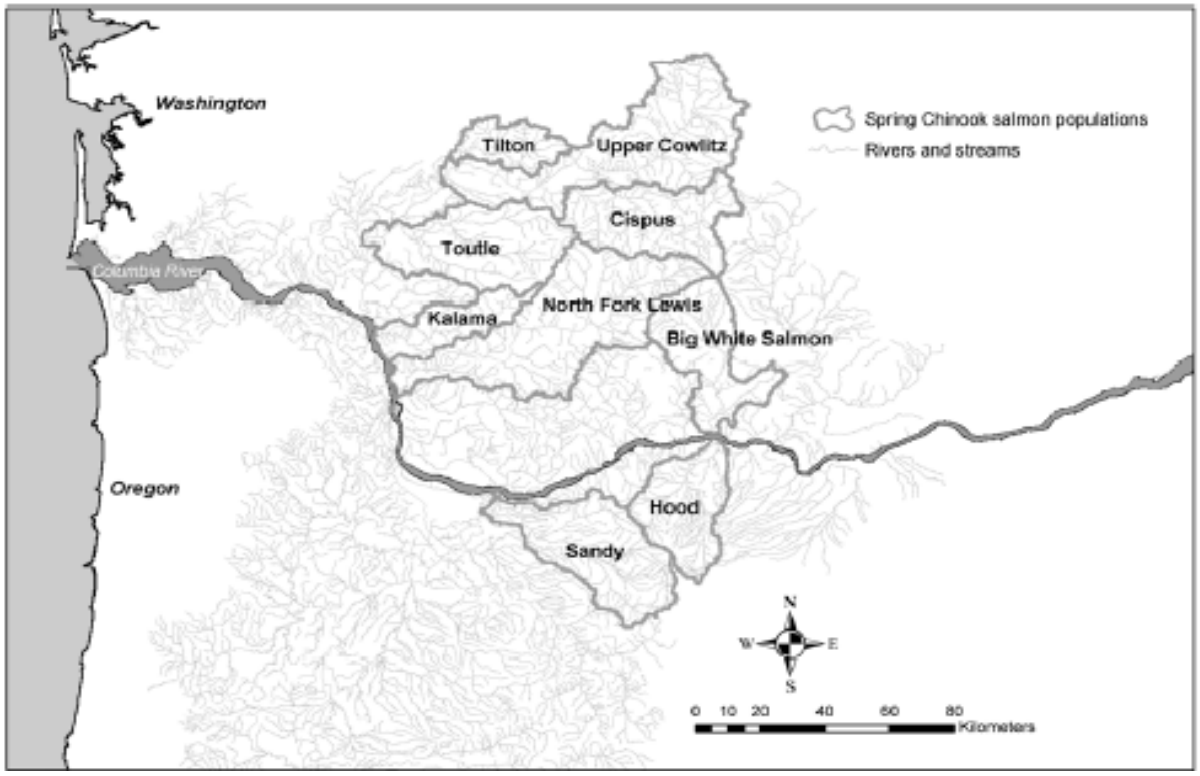

Figure 3. Historical independent LCR spring Chinook salmon populations (Myers et al. 2006).

Recent escapement estimates for Sandy River spring Chinook salmon are provided in the HGMPs (Table 5). 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 mi. above the mouth of Cedar Creek) to the Salmon River confluence,

[8] Clackamas River spring Chinook salmon are considered part of the listed Upper Willamette River Chinook salmon ESU.

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). 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 2008c).

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 modeling efforts 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 Figure 4. In ranking the VSP parameters, McElhany et al. (2007) developed population persistence categories (Table 4), that described the probability that a population would persist after 100 years. The higher the combined VSP parameter score the lower the probability of extinction, thus a score of 3.0 would equate to a 1-5% chance of extinction in 100 years, or in other words, the population would by highly viable and at low risk of extinction.

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	0–40%	60-100%	Either extinct or very high risk of extinction.
1	40–75%	25-60%	Relatively high risk of extinction in 100 years.
2	75–95%	5-25%	Moderate risk of extinction in 100 years.
3	95–99%	1-5%	Low ("negligible") risk of extinction in 100 years (viable salmonid population).
4	>99%	<1%	Very low risk of extinction in 100 years.

McElhany et al. (2007) determined that the Sandy spring Chinook salmon population was at a moderate risk of extinction. In evaluating the VSP parameters for abundance and productivity they compared the time series from 1961-2004 with the 1990-2004 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 1961-2004 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% reduction in accessible habitat due to the dams on the Bull Run Rivers. 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. They 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 introgression with out-of-stratum (MPG) hatchery broodstocks; and (3) Synthetic approach based on the fraction of hatchery origin spawners (i.e., pHOS). 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[9]. But this method does not apply to isolated 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. A thorough description of PNI is provided in Section 2.4.1.2 below. 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. The risk to the viability of the natural population from naturally spawning hatchery fish increases the more divergent the hatchery fish are from the natural population (i.e., risk from out of ESU/DPS > risk from out of MPG > risk from within 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% for a diversity score of 3 and less than 5% 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% for a score of 3 and less than 20% for a score of 4. McElhany et al. (2007) noted that the different types of mortality will 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

[9] 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.

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 2.0. The score for the effective population size element was 3.0, based on the estimated 28-year average abundance of 1,579 fish (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 stock and developing a locally-derived broodstock program using Sandy River spring Chinook salmon. During this time the trapping and removal of hatchery spring Chinook salmon was also initiated at Marmot Dam (i.e., 1999). The estimated PNI was < 0.65 above the dam and 0.25 below the dam leading to an overall score of 2.5 for this factor. The hatchery introgression factor score was 2.0 due to the introduction and long-term releases of Clackamas Hatchery stock spring Chinook salmon stock 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 low ($0.10<pHOS<0.30$), the score for the synthetic approach factor was 4.0 (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 1999-2002 the harvest rate was estimated to be 40.7%, 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 have resulted changes in the juvenile salmonid life histories. The score provided for the anthropogenic mortality element was 3-4.

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 (see Figure 4)(McElhany et al. 2007).

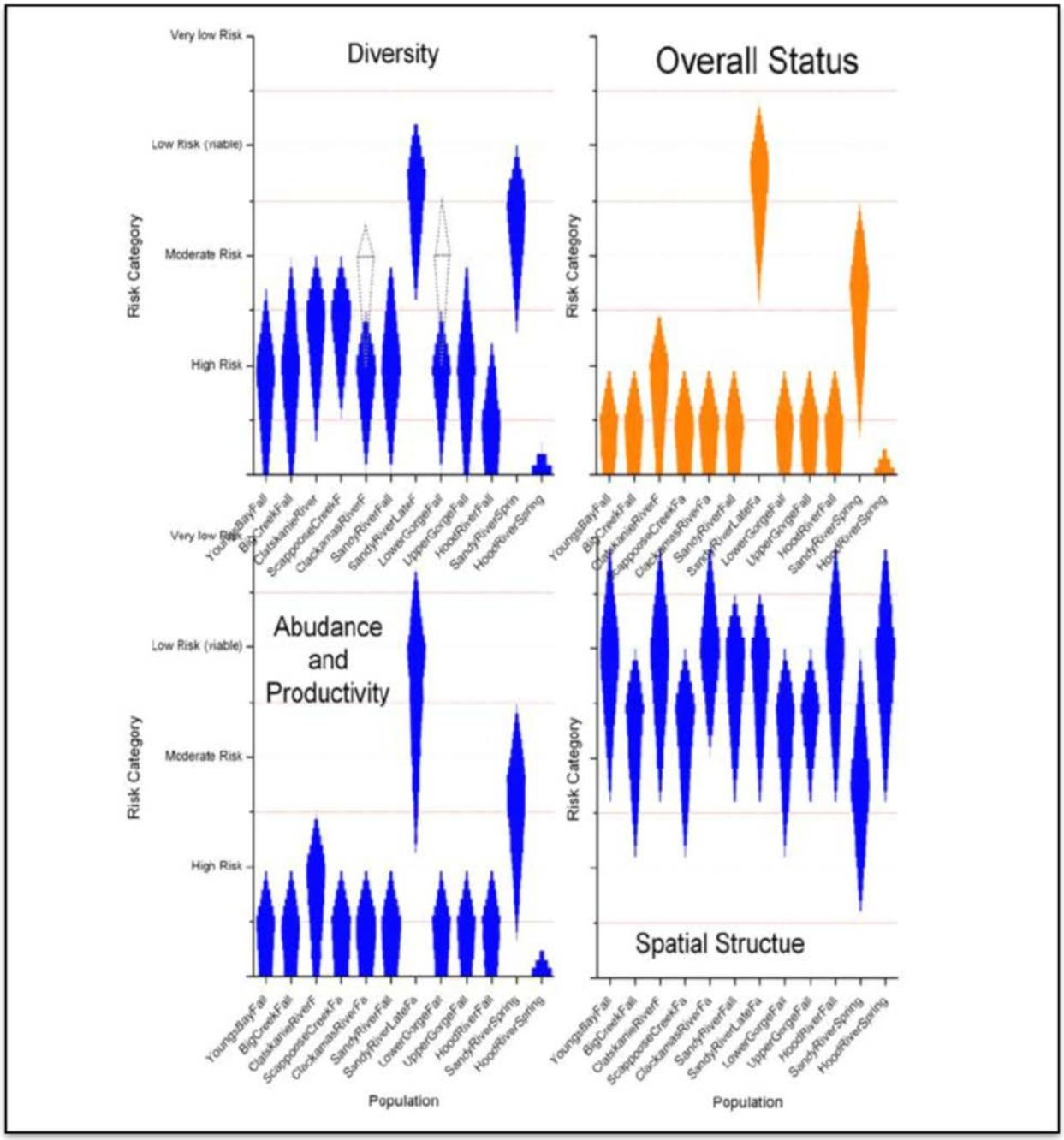

Figure 4. Oregon Lower Columbia River Chinook salmon status graphs and overall summery (Ford 2011).

Lower Columbia River Chinook salmon: Updated Risk Summary

Ford (2011) 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. For the Sandy River Basin, there are three Chinook salmon populations and each has a different status. On the positive side, 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 2010) (see Figure 4). It has maintained high spawner abundances since the last BRT evaluation (LCFRB 2010; ODFW 2010). On the other hand, the Sandy River tule fall Chinook salmon population is considered to be at very high risk (ODFW 2010). The Sandy River spring Chinook salmon population is considered to be at moderate risk (ODFW 2010) (Figure 4). Some of the factors affecting the VSP parameters have changed since the period considered by Ford (2011), and these changes are described in more detail in the Environmental Baseline below.

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).

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

[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 2010). 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.

The recovery plan for LCR salmon and steelhead (ODFW 2010) 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 hydro-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 2010), is for the population to be at low risk of extinction (< 5

percent probability or a persistence score of 3), 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 in Table 9-3 of the Recovery Plan (ODFW 2010). 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 nine years, of less than 0.10, or 10% (ODFW 2010).

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 (Table 4), identifying it as key to the recovery of the Cascade Spring Chinook salmon stratum, and the LCR Chinook salmon ESU as a whole.

2.2.1.2. Life History and Status of LCR River Coho Salmon

The Sandy River coho salmon population is part of the LCR Coho Salmon ESU. The LCR Coho Salmon ESU was listed as threatened under the ESA in 2005 (70 FR 37160) (Table 3). In 2001, the NMFS Biological Review Team (BRT) reconvened to update information on the biological status of LCR coho salmon after declining to consider the ESU for listing in 1995 (60 FR 38011). At that time, they reaffirmed the conclusion that it should be regarded as a separate ESU from southwest Washington (SWA) coho salmon (Brown 2001). This conclusion was supported by new tagging data and analyses indicating that SWA and LCR coho salmon populations have differing marine distributions and are genetically distinct (Shaklee et al. 1999; Brown 2001). This finding is consistent with the stock structure exhibited by LCR Chinook salmon and *O. mykiss* populations (McElhany et al. 2004) (Figure 5). The 2001 BRT also concluded that the historical ESU still exists in the LCR. The primary evidence to support this conclusion is the consistent genetic and life history differences between LCR coho salmon and populations from other areas. The BRT concluded that, because of presumably very low survival rates, stock transfers from Oregon coastal populations, 40-80 years ago, likely had relatively little permanent effect on the genetic makeup of LCR coho salmon. Nevertheless, the BRT recognized that evidence for appreciable natural production is limited to two Oregon populations (in the Sandy and Clackamas Rivers) that represent the clearest link to historical populations within the ESU (Brown 2001). Based on available information, most coho salmon returning to areas outside these two streams appear to be naturally spawning hatchery fish or progeny of naturally spawning hatchery fish. The 2001 BRT concluded that, collectively, these hatchery-produced fish, originating from the within the ESU, contain a key portion of the historical diversity of LCR coho salmon, albeit in somewhat altered form. In determining the upstream boundary of the LCR Coho Salmon ESU, the BRT (2003a) concluded that UCR coho salmon were likely a different ESU, and that the Cascade Crest represents the most likely eastern terminus of the LCR Coho Salmon ESU.

Based on the foregoing, NMFS concluded that the LCR Coho Salmon ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries from the mouth of the Columbia up to and including the White Salmon and Hood Rivers (Figure 5). NMFS identified 25 hatchery programs that were included as part of the LCR Coho Salmon ESU including the Sandy River hatchery coho salmon program (Ford 2011). The Sandy River hatchery program is not substantially diverged from the Sandy River coho salmon natural population. 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 2003b). In the analysis NMFS 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. It was not considered to be minimally divergent because the hatchery program did not incorporate substantial numbers of natural-origin fish into the broodstock. This assessment was used by NMFS to identify hatchery programs that would be considered to be part of the ESA-listed ESU. NMFS 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 integrated with the natural population.

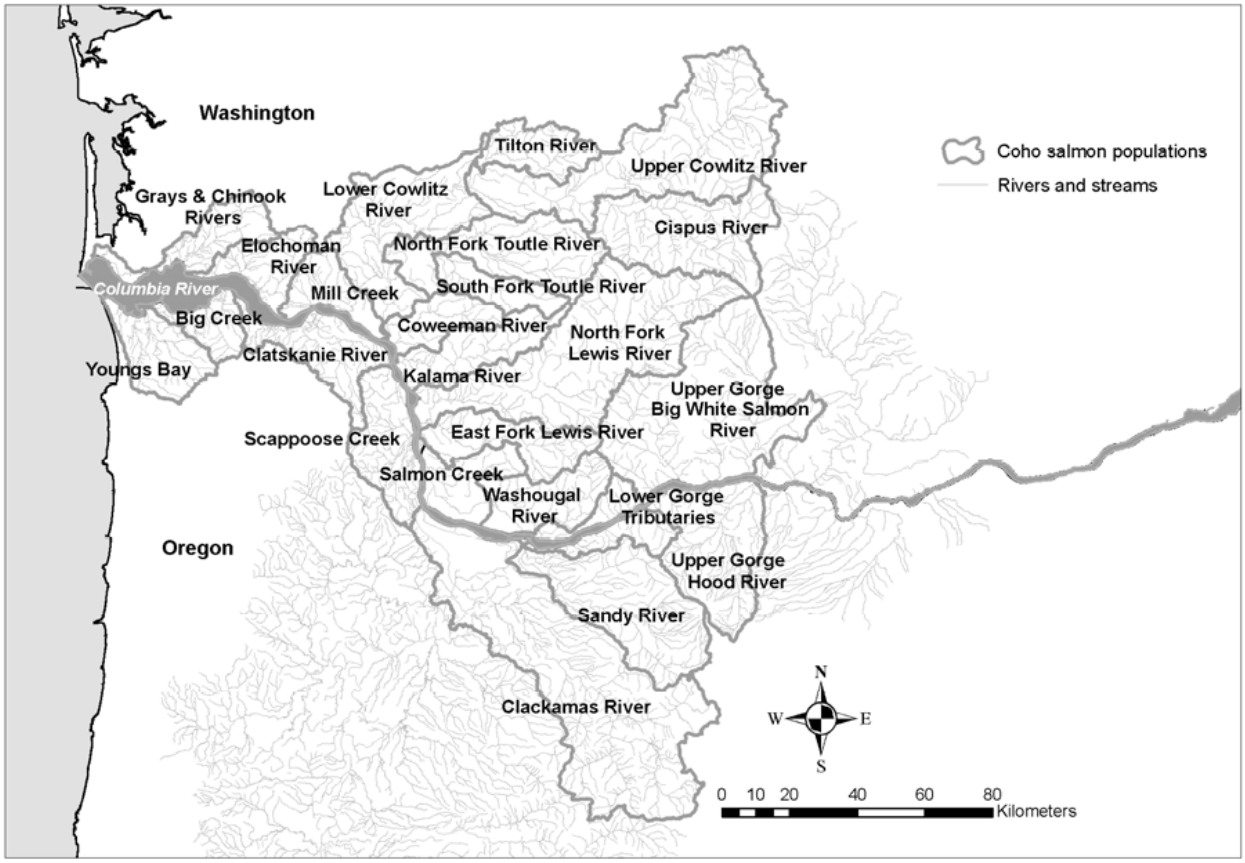

Figure 5. The LCR coho salmon ESU (from Myers et al. (2006)).

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.[10]
- Late-returning (Type N) coho salmon pass through the lower Columbia from late September through December and enter tributaries from October through January.[11] 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 three year generations, meaning that each broodyear tends to return at the same age of three years, except for a small proportion that return after 5-7 months at sea (commonly referred to as "jacks"). This is different than Chinook salmon and steelhead. As a 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.

In 2010, ODFW completed a recovery plan that addressed Oregon populations of LCR coho salmon (ODFW 2010) and the Lower Columbia Fish Recovery Board (LCFRB) completed a revision of its recovery plan that includes Washington populations of LCR coho salmon (LCFRB 2010). Both plans include an assessment of LCR coho salmon and both assessments relied and built upon the viability criteria developed by the Willamette Lower Columbia (WLC) Technical Recovery Team (TRT) (McElhany et al. 2006) and an earlier evaluation of Oregon WLC populations (McElhany et al. 2007). These evaluations assessed the status of populations based on VSP parameters (McElhany et al. 2000). The conclusion was that all of the Washington coho salmon populations and all but two of the Oregon populations are at "very high risk". Two populations in Oregon, the Scappoose and Clackamas, were considered by ODFW to be in the moderate risk category Figure 6.

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

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 2008c).

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 <1.5, or high risk of extinction because the mean abundance level had declined when comparing the two evaluation periods (1960-2005 and 1990-2005) and because one cohort was substantially lower than the other two.

At the time that the evaluation was completed, approximately 30% of the habitat that had been historically used by the Sandy River population has been blocked by dam construction on the Bull Run and Little Sandy Rivers, plus the 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 have occurred. The score for the life history traits element was 3.0. The score for the effective population size element was 3.0, 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%, over the last decade (thru 2004). This was based on 10% of the coho salmon production area being below Marmot Dam, and the remaining 90% above (as described above), and that the pHOS below the dam was high (>80%) in most years, but above the dam it was less than 5%. In addition, while evaluating this element, they considered that the hatchery program has been in operation for over 18 generations, has had <5% 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 2.0.

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 3-4 (McElhany et al. 2007). The synthetic approach

factor used the estimated 10% pHOS for the entire basin, and the same information discussed above and gave the factor a score of 3.0.

With regards to the anthropogenic mortality element, harvest rates ranged from 75% to 90% from the 1950s to the 1990s and now range between 20% and 35%. 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 2.0. 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 6).

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 6). This is considerable better than the extinction risk calculated for the ESU which is considered at very high risk.

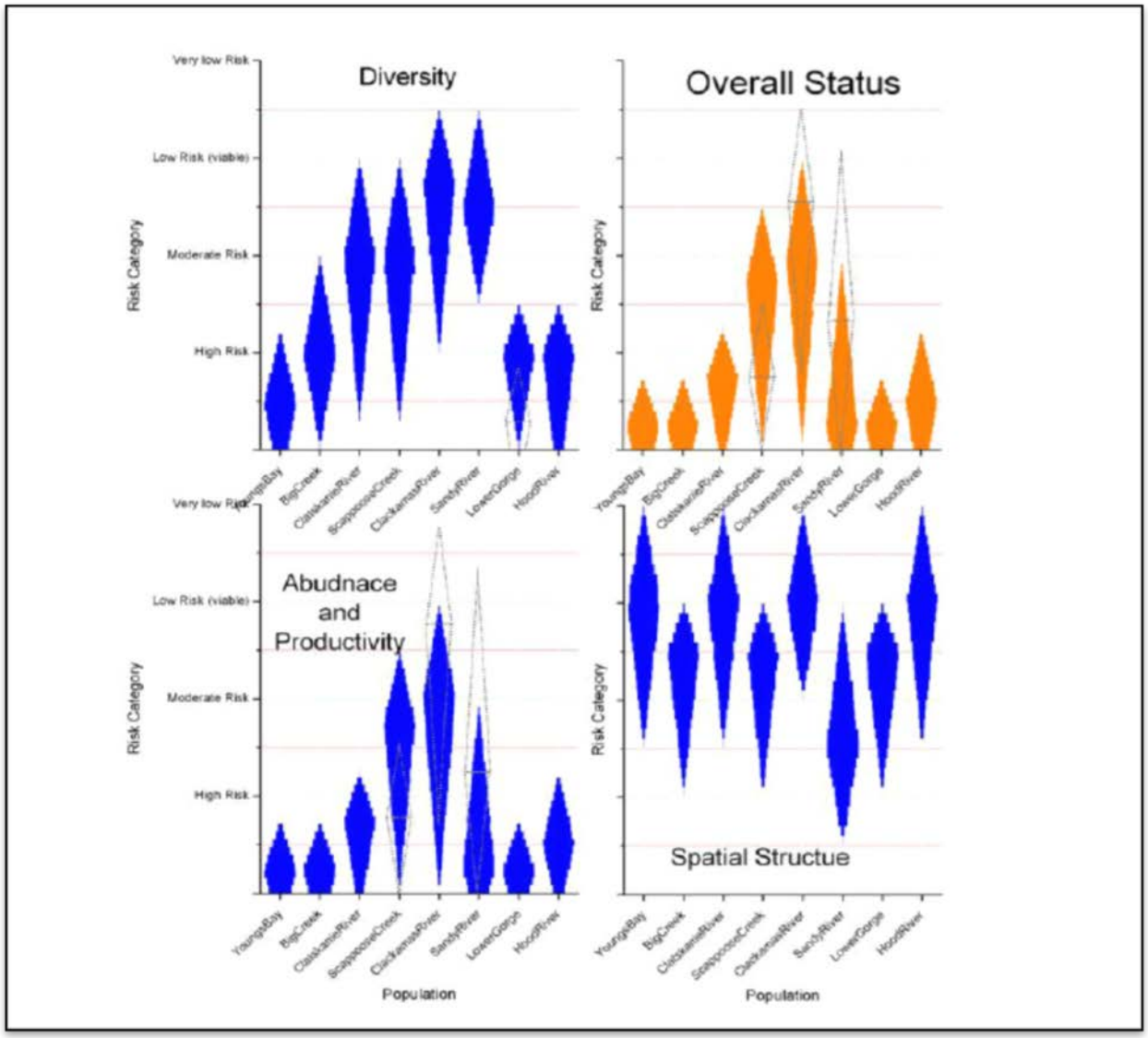

Figure 6. Extinction risk ratings for LCR coho populations in Oregon for the assessment attributes abundance/productivity, diversity and spatial structure as well as an overall rating for populations that combines the three attribute ratings. Where updated ratings differ from those presented by McElhany et al. (2007), the older rating is shown as an open diamond with a dashed outline (Ford 2011).

Lower Columbia River Coho salmon: Updated Risk Summary

Ford (2011) updated the status review completed in 2005 (Good et al. 2005) and concluded that consistent with previous evaluations, the LCR coho salmon ESU is at very high risk of extinction. Of the 27 historical populations in the ESU, 24 are considered at very high risk. The remaining three, Sandy, Clackamas and Scappoose, are considered to be at moderate to high risk. Note that ODFW (2010) 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 6). Factors affecting

the VSP parameters have changed since the period considered by Ford (2011) and ODFW (2010), and these changes are described in more detail in the Environmental Baseline below.

For coho salmon in the Sandy River Basin, the conservation and recovery plan for Oregon populations of salmon and steelhead (ODFW 2010) identified reduced habitat complexity and diversity; access to off-channel habitats; reduced and degraded estuary habitat from hydro-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 and this problem has since been fixed.

The recovery goal for Sandy River coho salmon, as described in Oregon's recovery plan (ODFW 2010), is for the population to be at a low risk of extinction (< 5 percent probability of extinction or a persistence score of >3.0) with an annual abundance of at least 5,685 natural-origin adults. The plan identified one hatchery action that would benefit coho salmon recovery and this action is in Table 9-3 of the Recovery Plan (ODFW 2010).

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.

2.2.1.3. Life History and Status of LCR Steelhead

The Sandy River winter steelhead population is part of the LCR Steelhead DPS. The LCR Steelhead DPS was first listed as threatened under the ESA in 1998 (63 FR 13347) and the listing as threatened was reconfirmed in 2006 (71 FR 834) (Table 3). The DPS includes all naturally produced steelhead in tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington State and between 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 7, summer steelhead are not shown). Steelhead in this DPS belong to the coastal genetic group (Schreck et al. 1986; Reisenbichler et al. 1992; Chapman et al. 1994) and include both winter steelhead (Cowlitz, Toutle, Coweeman, Kalama, Washougal, Sandy, Hood, Clackamas and Wind Rivers) and summer steelhead (Kalama, Lewis, Hood, Wind, and Washougal Rivers). The WLCR TRT (Myers et al. 2003), identified 23 historical populations within the DPS and determined that four of these have been extirpated (Figure 7, summer steelhead are not shown). Hatchery programs using endemic natural stocks of winter steelhead have been developed in the Cowlitz, Sandy, Kalama, and Hood River basins and are included in the DPS (71 FR 834; (Jones 2011)). 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 (2003b), NMFS (2004b), and Jones (2011).

Oncorhynchus mykiss has an anadromous form, commonly referred to as steelhead, of which LCR steelhead are a DPS. 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 or capable of spawning more than once before death.

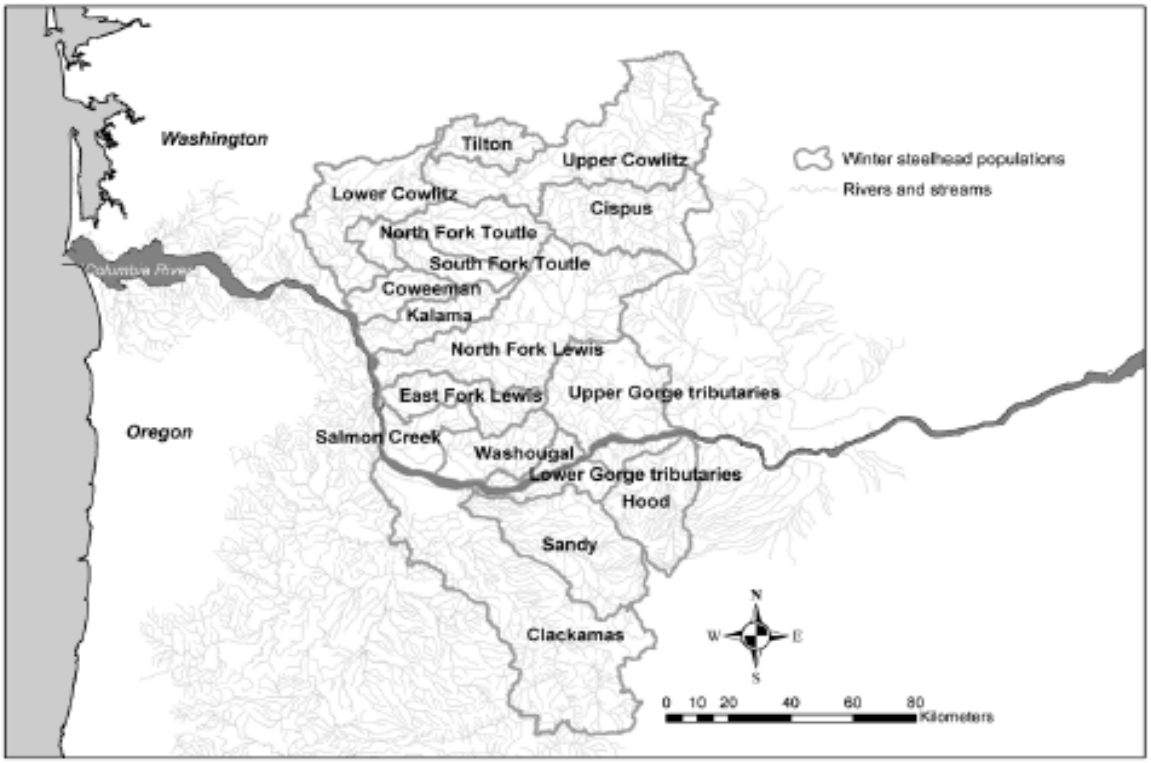

Figure 7. The LCR winter steelhead DPS (from (Myers et al. 2006)).

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.

Based on catch data, juvenile steelhead tend to migrate directly offshore during their first summer, rather than migrating nearer to the coast as do salmon. During fall and winter, juveniles move south and eastward (Hartt and Dell 1986). Available fin-mark and coded-wire tag data suggests that winter steelhead tend to migrate farther offshore but not as far north into the Gulf of Alaska as summer steelhead (Burgner et al. 1992). Maturing Columbia River steelhead are

found off the coast of Northern British Columbia and west into the North Pacific Ocean (Busby et al. 1996).

No estimates of historical abundance (pre-1960s) are available for the LCR steelhead DPS. Since 1996 when the ESA status review was completed, LCR steelhead populations have generally increased, with some populations rebounding more quickly than others.

Busby et al. (1996) identified a number of factors contributing to the decline of steelhead in this DPS. Hatchery practices were identified as a limiting factor in addition to barriers limiting spatial structure and abundance and habitat degradation reducing steelhead productivity. The widespread and intensive production of hatchery steelhead within this DPS is thought to have reduced steelhead productivity and diversity where there appears to be substantial overlap in spawning between hatchery and natural fish (Busby et al. 1996). Some hatchery fish are derived from local populations (e.g., the Sandy Hatchery winter steelhead program) and are included in the DPS but most are not. The summer steelhead populations appear to be more at risk from habitat degradation than winter steelhead. Exploitation rates (i.e., the sum total of all harvest impacts) have ranged from 20% to 50% for hatchery and natural-origin fish combined, but exploitation rates on natural-origin steelhead are low, between 0% and 4% since the 1990s, due to regulations designed to protect natural-origin adult and juvenile steelhead.

A major area of concern is the level of interaction, genetic and ecological, between hatchery steelhead and natural populations of winter and summer steelhead. There is some indication that under the present conditions overlap in spawning between natural and hatchery fish may be limited (i.e., hatchery-origin steelhead spawning naturally are largely isolated from natural-origin steelhead spawners). However, with the exception of detailed studies of the Kalama River winter population that show there is separation (Leider et al. 1984), this conclusion is based largely on models with assumed run timing rather than empirical data. Busby et al. (1996) reported that there is little or no information on interactions between hatchery and natural-origin steelhead on the Oregon side of the LCR. More recently Chilcote (2001) and Kostow and Zhou (2006) have observed ecological interactions in the Clackamas River between hatchery and natural-origin steelhead and have concluded that these interactions have resulted in reduced productivity for the winter steelhead population.

ODFW estimates that 70 percent of the spawning habitat for winter steelhead in the Sandy River is located above the former Marmot Dam site (SRBP 2005). ODFW ended releases of hatchery summer steelhead at Marmot Dam and upstream locations in 1998. Furthermore, the preferred spawning habitat for winter steelhead is some distance upstream from the Sandy Hatchery where both winter and summer hatchery steelhead are encouraged to return, based on best management practices followed by the hatchery.

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%, 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 1.0 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 MPG. They concluded that there was little available information to determine if life history changes had occurred and provided a score of NA 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 2-3.

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 an NA. 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 (<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 3.0 (McElhany et al. 2007).

McElhany et al. (2007) concluded a score of NA for the anthropogenic mortality element even though harvest rates have declined from an average 40% prior to 1991, to approximately 4% 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 they gave the anthropogenic mortality element a score of NA. The habitat diversity element was given a score of 2/3 due to the fact that the quality of the habitat has been severely degraded.

The resulting overall score for the diversity parameter was 2.0, 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 8).

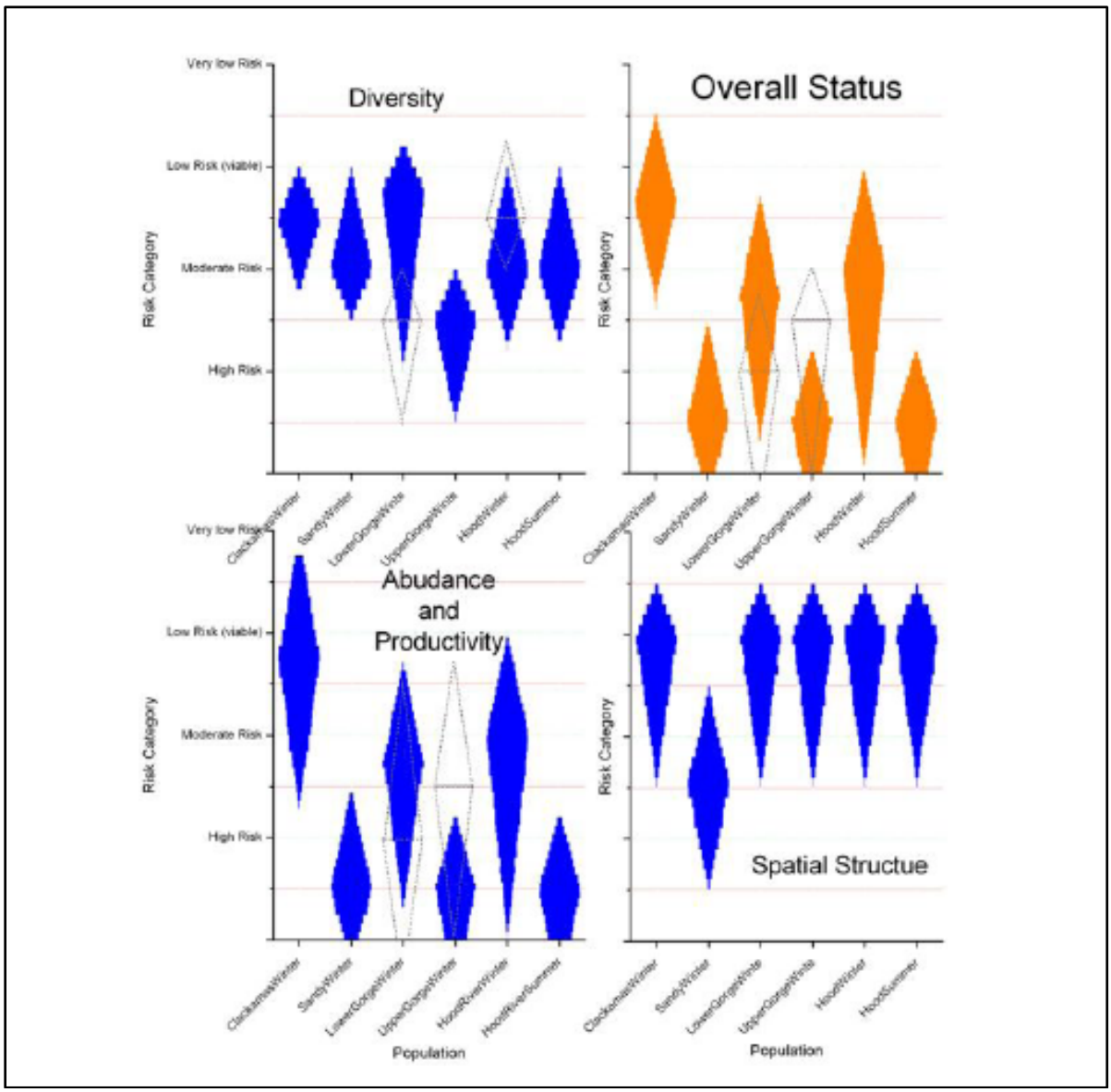

Figure 8. Oregon LCR steelhead population status from (Ford 2011).

Lower Columbia River steelhead: Updated Risk Summary

Ford (2011) updated the steelhead status review completed in 2005 (Good et al. 2005). Three status evaluations of LCR steelhead, all based on WLC-TRT criteria, have been conducted since the last BRT status update in 2005 (McElhany et al. 2007; LCFRB 2010; ODFW 2010). All three evaluations concluded that the LCR Steelhead DPS is at high risk. Of the 26 historical populations in the ESU, 17 are considered at high or very high risk. Factors affecting the VSP parameters have changed since the period considered by Ford (2011) and ODFW (2010), and these changes are described in more detail in the Environmental Baseline below.

For Sandy River winter steelhead, Table 5 provides escapement information for the Sandy River. Note that prior to 2007 estimates of abundance and pHOS were based solely 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. The 2010, survey included only 7 individuals with known marks identifying them as either a hatchery fish or a natural-origin fish, and the 2011 and 2012 surveys included 19 and 3 known mark individuals respectively. The very low number of known mark fish for these years resulted in very unreliable estimates of pHOS for those return years. In 2013, the surveys were expanded and the sample size increased to 47 known mark individuals. This resulted in an estimated total return of 3,747 adults of which 3,509 were natural-origin winter steelhead (ODFW 2013g). The pHOS estimate for 2013 was 6.4%. The expanded spawning ground surveys are expected to continue into the future and are expected to increase our confidence in the abundance and pHOS estimates.

The conservation and recovery plan for Oregon populations of LCR salmon and steelhead (ODFW 2010) identified reduced habitat complexity and diversity, including access to off-channel habitats; reduced estuary function from hydro-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 2010), is for the population to be at very low risk of extinction (< 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 2010).

In the NMFS' LCR Recovery Plan (NMFS 2013c), the Sandy River 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.

2.2.2. Status of Critical Habitat

NMFS has reviewed the status of critical habitat affected by the proposed action. Critical habitat is designated for LCR Chinook salmon and for LCR steelhead in the Sandy River basin within the Action Area (September 2, 2005; 70 CFR 52630) (Table 3). Critical habitat includes the stream channels within the proposed stream reaches, and includes a lateral extent as defined by the OHWL (33 CFR 319.11).

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

For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each listed species they support[12]; the conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' critical habitat analytical review teams (CHARTs; (NMFS 2005a)) evaluated the quantity and quality of essential physical and biological features (for example, spawning gravels, wood in the stream channel, water quality and quantity, and side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Thus, even a location that has poor quality habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), if it served a unique population (e.g., a population at the extreme end of geographic distribution), or the fact that it serves another important role (e.g., an obligate area for migration to upstream spawning areas).

This section examines critical habitat condition for the affected salmonid species. The analysis is combined (for Chinook and coho salmon, and steelhead) because of the similarity of essential physical and biological features for each species, and the overlapping critical habitat areas.

The Action Area for this proposed action are tributary streams in the Sandy River basin accessible to anadromous fishes and the Sandy River itself downstream to its confluence with the Columbia River, as well as the out of basin facilities utilized by the programs and the adjacent stream segments, as described above. Primary Constituent Elements (PCEs) consist of the physical and biological elements identified as essential to the conservation of the species. LCR Chinook, and coho salmon and steelhead have overlapping ranges, similar life history characteristics and, therefore, share many of the same PCEs. These PCEs include sites essential to support one or more life stages (sites for spawning, rearing, and migration) and contain the physical and biological features essential to the conservation of each species. Essential features, for example, include spawning gravels, forage species, cover in the form of submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction with sufficient water quantity and quality.

For all of the listed species affected by these programs, the watersheds that are within the Action Area (as described in Section 1.4) have been designated as essential for spawning, rearing, juvenile migration, and adult migration. In the Action Area, the major factors affecting PCEs are the same as those habitat related limiting factors described for each of the listed species above, including reduced habitat complexity and diversity; and access to off-channel habitats (ODFW 2010). Land use practices such as channelization, diking, wetland conversion, stream clearing, splash damming, and gravel extraction have severed access to historically productive habitats, simplified many remaining tributary habitats, and interfered with the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production.

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

No new permanent facilities are being proposed for these hatchery programs. The facilities used for the proposed hatchery programs are located high in the floodplain and have not led to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity. These facilities are designed and used such that they do not reduce access to spawning and rearing habitat, or increase water temperatures.

What could affect essential physical and biological features in the Sandy River Basin is the installation and operation of temporary weirs in certain tributaries. The installation and operation of the weirs to collect hatchery spring Chinook salmon may affect PCEs for rearing and freshwater migration. PCEs that may be affected by the operation of supporting hatchery facilities outside the Sandy River Basin include rearing and freshwater migration. These factors are considered in the effects analysis below (see Section 2.4.1).

2.2.3. Climate Change

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

- Warmer air temperatures will result in diminished snowpacks and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, these watersheds will see their runoff diminished earlier in the season, resulting in lower streamflows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower streamflows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007).

To mitigate for the effects of climate change on listed salmonids, the ISAB (2007) recommends planning now for future climate conditions by implementing protective tributary, mainstem, and estuarine habitat measures, as well as protective hydropower mitigation measures. In particular, the ISAB (2007) suggests: increased summer flow augmentation from cool/cold storage reservoirs to reduce water temperatures or to create cool water refugia in mainstem reservoirs and the estuary; and the protection and restoration of riparian buffers, wetlands, and floodplains.

2.3. Environmental Baseline

In this section we describe the environmental baseline on which we will evaluate the effects of the Proposed Action. The environmental baseline provides the background information on what has been affecting the ESA-listed populations in the Action Area leading to their status as described above in Section 2.2.1. The environmental baseline section also describes changes that have occurred since those status determinations were made and whether these changes would have affected those status determinations. Under the Environmental Baseline, NMFS describes what is affecting ESA-listed species and designated critical habitat in the Action Area, including both beneficial and adverse effects, before including any effects resulting from the proposed action. The 'environmental baseline' includes the past and present effects of all Federal, state, or private actions and other human activities in the action area and the anticipated effects of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation (50 CFR 402.02). The effects of future actions over which the Federal agency has discretionary involvement or control will be analyzed as 'effects of the action.'

As an introduction or precursor for determining what is affecting ESA-listed species and designated critical habitat under the Environmental Baseline, Section 2.2 of this opinion describes how population viability relates to the status of ESA-listed species in the wild, defines the parameters that determine viability (i.e., abundance, productivity, diversity, and spatial structure), and then analyzes and describes the status of these parameters for ESA-listed species in the Action Area. The next step is to identify and evaluate what is affecting these parameters. In the section below, we report on the past and present effects of all Federal, state, or private actions, and other human activities in the Action Area on these parameters and on designated critical habitat along with the anticipated effects of all proposed Federal projects in the Action Area that have already undergone formal or early Section 7 consultation (50 CFR 402.02). We will build on the scientific principles in McElhany et al. (2007) and Oregon's recovery plan (ODFW 2010) and describe what actions have occurred since the development of those reviews and how these changes may have affected VSP parameters to determine the environmental baseline that will be used for the evaluation of the Proposed Action.

Effects on Viability Parameters and Designated Critical Habitat in the Action Area

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. More recently, there have been changes in regulations and management practices and remediation of several factors, and these changes are resulting in improving conditions for ESA-listed salmon and steelhead in the Action Area (NMFS 2008c; ODFW 2010; NMFS 2012d).

Resource Development

Originating from glaciers on the eastern 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. 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 in the Section 2.2, 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 Action Area 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 (NRI) 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 NRI from 1982-1997, 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 actions substantially decreased the complexity and productivity of the habitat and contributed to a decline in natural production.

Habitat Restoration Programs

There have been important habitat restoration initiatives in the Sandy River Basin, largely since salmon and steelhead in the Sandy River gained protection under the ESA, and these initiatives have started a healing process that is expected to address some of the major factors limiting salmon and steelhead abundance productivity, and spatial structure. 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 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 2008e; 2014). They 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. They are: 1) large wood, boulder, and gravel placement, 2) reconnecting existing side-channels and alcoves, 3) head-cut stabilization and associated fish passage, 4) streambank restoration, 5) fish passage at culverts and bridges, 6) screen installation and replacement at irrigation diversions, 7) nutrient enhancement, 8) floodplain overburden removal, 9) reduced recreation impacts, 10) estuary restoration, 11) riparian vegetation treatment (non-commercial, mechanical), 12) riparian and upland juniper treatment (non-commercial), 13) riparian vegetation treatment (controlled burning), 14) invasive plant control, 15) fencing riparian areas (with water gaps and stream crossings), 16) riparian vegetation plantings, 17) reducing sediment

input from roads, 18) removal of legacy structures, and 19) fisheries, hydrology, geomorphology, wildlife, botany, and cultural surveys in support of aquatic restoration (NMFS 2008f; 2013b; 2013a).

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 which 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 the Clear Creek, Zigzag River, and Salmon River; boulder placement at multiple sites in the Zigzag and Salmon rivers; as well as invasive plant control, riparian plantings, and road obliteration throughout the basin (PNSHP 2014). The PNSHP (2014) has a database that is 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 2007b). 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 fund supplements 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 funded projects are tracked by a database separate from those projects tracked by the PNSHP and so are in addition to those described previously. The PCSRF has made substantial progress in achieving program goals, as indicated in Reports to Congress, workshops and independent reviews.

A number of projects have been completed in the Sandy River Basin and many projects are ongoing. Examples of completed PCSRF funded projects in the Sandy River Basin include restoration of .63 miles of the Salmon River where a pool was excavated, and boulders were placed instream along with large woody debris and anchored habitat structures to reconnect and improve access to side channels (OWEB 210-3005-7391)(PSCRF 2014). Another project in the Salmon River where a side channel was reestablished, a road was decommissioned, large woody debris was placed into the stream,

riparian areas were planted and a culvert was removed. This project treated .90 miles of stream habitat and 120 acres of riparian habitat (OWEB 208-7003-6839) (PSCRF 2014). In the lower Sandy River, an eight mile stretch of river is being treated over a number of years, and the first phase included the reconnection of 1,825 feet of side channel and the realignment of 2,000 feet of a perennial tributary, Happy Creek (OWEB 212-3025-8913) (PSCRF 2014). In the lower Salmon River, a project rehabilitated an old quarry by placing instream anchor habitat structures, planting riparian vegetation and improving access to reconnected side channels. This project affected .23 miles of stream and .8 acres of riparian habitat (OWEB 211-3039-8568) (PSCRF 2014). A project in Still Creek reactivated 1.54 miles of side channels through the installation of 250 pieces of large wood, treated 16 acres of riparian habitat by planting trees and shrubs and by removing invasive plants (OWEB 210-8000-8986) (PSCRF 2014).

The lower Sandy, including the river delta, is important habitat for fish and two projects are nearly completed that will 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 then were trapped and perished when the water receded. Both projects also will 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.

Municipal Water Supply and Hydropower Development

The quantity and quality of habitat in the Action Area has also been affected by municipal water supply activities which 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), and Ben Morrow Dam in 1929. 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 will remain inaccessible to salmon and steelhead, and this will 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 will 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 (Bureau 2013). These actions, along with the flow changes are expected to improve productivity in the lower Bull Run River for spring Chinook salmon.

Hydroelectric power facilities were developed on the Sandy and Little Sandy Rivers in the early 1900s. 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-high 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. 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.

Beginning in 1999, the fish ladder at Marmot Dam was used to trap and remove hatchery adults and this resulted in a *defacto* “wild fish sanctuary” above the dam. The fish ladder however, was not designed and was never intended to trap and remove adult salmon and steelhead, and thus the operation proved harmful to natural-origin fish that were mixed together and handled with hatchery fish (Doug Cramer, PGE personal communication). In 2007, Marmot Dam and its associated facilities were removed, ending the ability to trap and removed and this was followed in 2008 by the removal of the diversion dam on the Little Sandy River.

In 2010, ODFW announced their intention to identify and manage areas in the LCR in Oregon above existing fish trapping facilities as “wild fish sanctuaries” (ODFW 2010). Areas would be managed as “wild fish sanctuaries” where it was convenient, 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). The removal of Marmot Dam, three years previous to this announcement, meant that areas upstream would not

likely qualify as a “wild fish sanctuary” where that definition is based on the absence of hatchery spawners. Nevertheless, it remains important habitat to salmonid recovery, and the 2012 HGMPs included changes in hatchery operations and the operation of weirs in the upper Sandy River Basin, designed to control and reduce the influence of hatchery spring Chinook salmon in the upper Sandy River.

The removal of Marmot Dam and the Little Sandy River Diversion is expected to have 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 contribute to recovery.

On top of 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, we are seeing 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 Chinook salmon, coho salmon, and steelhead eggs 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 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 and in some years 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 (out-of-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 9). Beginning in the 1970s, production at the Sandy Hatchery changed and it only produced coho salmon for release on station (Taylor 1998). Spring Chinook salmon and steelhead from sources outside the Sandy River Basin continued to be released into the Sandy River and its tributaries (see individual species hatchery program discussions below).

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). NMFS identified that the greatest effect on LCR steelhead from these artificial propagation programs was from impacts on productivity and diversity caused by the natural spawning of non-endemic steelhead. 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 stock winter steelhead program and transitioning to a locally-derived Sandy River winter steelhead stock program; and until the transition to the locally-derived stock was complete, restricting the release of Big Creek stock winter steelhead in the Sandy River to below Marmot Dam beginning in 1999 (NMFS 1999). The RPAs also 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 that remedied 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).

As described above, 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.

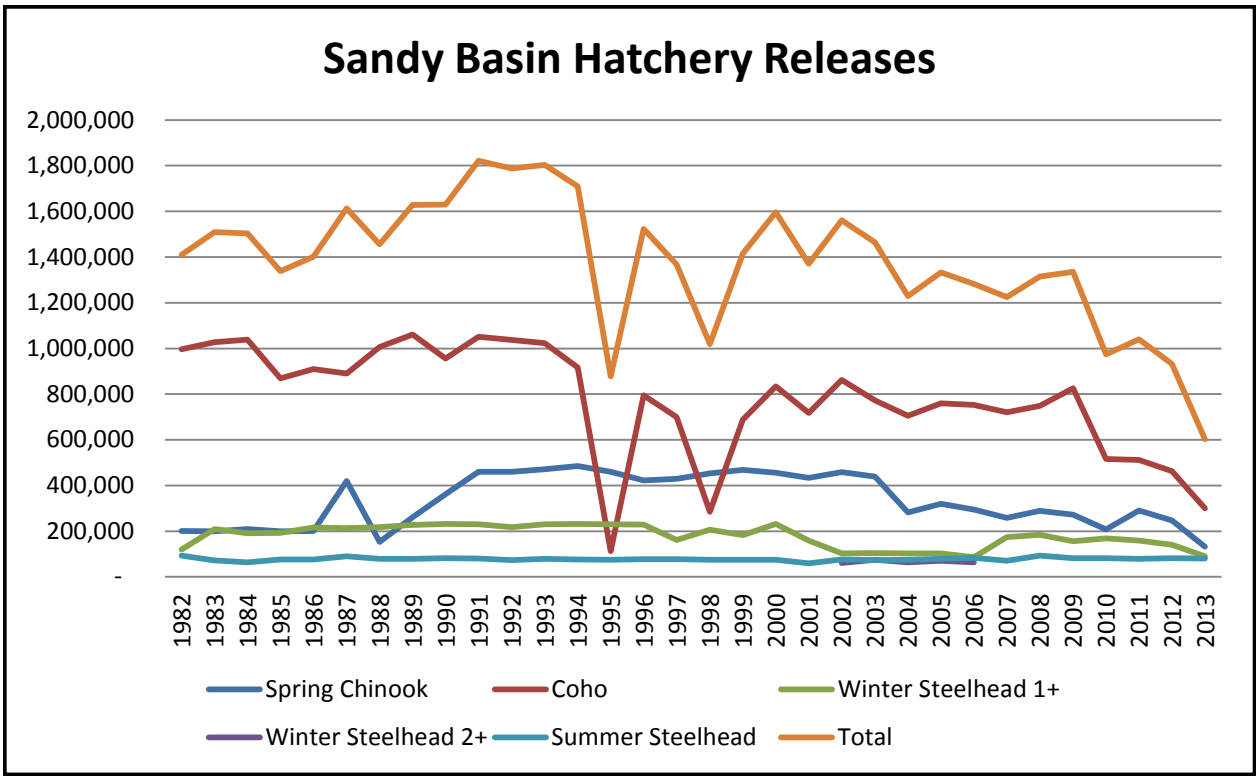

Figure 9. Sandy River Basin hatchery releases by year of release from 1982 to 2013. Data from 1997 draft Sandy River Basin Management Plan (ODFW 1997), Sandy HGMPs (ODFW 2013g; 2013e; 2013c; 2013b), and queries into the Fish Passage Center Hatchery Database.

The environmental baseline also includes past effects of hatchery operations authorized in 2012. The effects of continued hatchery operations under that authorization are not included in the baseline, since the Proposed Action consists of replacing those previously authorized programs.[13]

[13] The previous authorizations were the subject of litigation, which as of this writing resulted in a finding that the authorizations lacked sufficient NEPA and ESA consideration. The 2012 authorizations remained largely in effect, and effects incurred under the 2012 authorizations prior to this opinion are included in the environmental baseline.

Below we look how the different 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).

Spring Chinook Salmon Program

For Sandy River spring Chinook salmon, some reduction in the VSP parameters likely occurred during the twenty to thirty year period when broodstock practices used fish originating from outside the Sandy River Basin, and pHOS was high. As described above, 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 9) and there was growing 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). 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 spring Chinook salmon stock (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).

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 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 9). In 2002, all of the returning Clackamas Hatchery spring Chinook salmon were distinguishable from other spring Chinook salmon except for a very small percentage (<2%) 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%) of the broodstock consisted of natural-origin adults, the rest consisted of hatchery returnees. 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 stock 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 2003b; 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 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 a surrogate for hatchery-influenced selection (see discussion in Section 2.4.1.2).

Recent surveys have shown a declining trend in pHOS for spring Chinook salmon (Table 6). 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% (Table 6). These levels far exceeded the management and recovery plan pHOS goal of <10% (ODFW 2010). 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 PNI[14] should exceed 0.67 (see detailed discussion of PNI in Section 2.4.1.2). As described in Section 2.4.1.2, PNI is a function of pHOS and pNOB (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 meet 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. Any PNI > 0.50 indicates dominance of natural selective forces over hatchery selective forces. 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%, which was consistent with the recovery and management goal of a pHOS <10%.

[14] This metric was not considered in the previous biological opinion because natural-origin adults were not incorporated into the broodstock and thus the primary management goal was to achieve the pHOS goal of <10%.

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

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 affect 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 shows that Sandy River spring Chinook salmon were still intermediate between the two ESUs and the effects of genetic introgression were still present. There is 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.

Coho Salmon Program

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%, 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 1952-53 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)(see Figure 9).

Hatchery coho salmon production was not distinguishable from natural-origin coho salmon until after the 1997 broodyear when 100% were 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% (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 2). After the removal of Marmot Dam, basin-wide spawning surveys were conducted annually and the estimated pHOS varied from 0 to 12.4% 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%) and 2012 (2.8%) reflect annual releases of 500,000 smolts that began in 2010 (Figure 9). The estimated high pHOS of 12.4%, observed in 2010, corresponds to a very large release of 826,083 smolts in 2009. The pHOS in 2013 of 11.8% was from a release of approximately 463,000 smolts.

Effects of hatchery coho on the natural-origin population have occurred and were most likely due to the large releases of smolts (Figure 9). Even with these large releases from the Sandy Hatchery few adult hatchery coho from these large releases were observed at Marmot Dam (Table 2). When Marmot Dam was removed, the basin-wide spawning ground surveys found that pHOS was low as described above. The hatchery coho salmon program has not incorporated natural-origin adults into the broodstock and when they did it was only a small proportion of the broodstock and at levels that would not meet HSRG guidelines (see Section 2.4.1.2 below) (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 2003b; 2004b; Ford 2011; Jones 2011), and therefore NMFS considers the hatchery program to be integrated with the natural population.

Winter Steelhead Program

Beginning in the mid-1960s, Big Creek stock early-winter steelhead and in some years Eagle Creek NFH winter steelhead were released into the Sandy River (Figure 9). Both of these are out-of-basin stocks and there was the potential for genetic introgression based on average pHOS estimates of 43% (Chilcote 1998). The risk was such that NMFS, in its 1999 Jeopardy Opinion, determined that the release of Big Creek stock winter steelhead was jeopardizing the winter steelhead population in the Sandy River (NMFS 1999).

After issuance of the ESA jeopardy opinion with RPAs, several actions were taken to ameliorate the affects from the release of Big Creek stock 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 2000-2002, broodstock was comprised of 100% natural-origin Sandy River winter steelhead collected at Marmot Dam and from 2005 to 2010, a maximum 38% of the broodstock was composed of natural-origin winter steelhead. In 2011 this decreased to 18%, and for broodyears 2012-2014 only hatchery adults returning to the Sandy Hatchery were used for broodstock. The smolt release goal was 180,000 smolts and in some years (2002-2006) included releases of up to 74,000 2-year old smolts (Figure 9). So, the

hatchery program improved in two important ways – it changed to an appropriate, locally-derived broodstock and in properly sized the program from smolt releases of over 200,000 in the 1980s and 1990s to 160,000 beginning in 2009 (Figure 9) (ODFW 2013g).

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 2 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%. 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 7 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 what is important is that each of them were in close proximity to the hatchery and could have ultimately returned there thus altering the final estimate of pHOS (Schroeder 2013). By the same token, small sample sizes like this could also underestimate pHOS. The 2011 and 2012 estimates were not much better, based on 19 and 3 known-mark individuals. These small sample sizes call into question pHOS estimates for 2010, 2011, and 2012 and our confidence in these estimates is very low.

In 2013, the surveys were expanded to provide more data and generate better estimates of the abundance and pHOS and to ensure that the hatchery programs, as described in the 2012 HGMPs, were meeting the terms and conditions in the opinion. As a result of this expanded effort, the sample size in 2013, increased to 47 known mark individuals. This resulted in an estimated total return of 3,747 adults of which 3,509 were natural-origin winter steelhead (ODFW 2013g). The resulting pHOS estimate for 2013 was 6.4%. The expanded spawning ground surveys are included in the Proposed Action and will be necessary to increasing and maintaining confidence in estimates of abundance and pHOS going forward.

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 – a potential benefit but one requiring more careful consideration. 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 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 will be monitored using a rotary screw trap to collect juvenile outmigrants (see Section 1.3.5). Under the Proposed Action, no hatchery winter

steelhead will be passed above the hatchery for a period of five years (through 2019), at which time the success of the recolonization will be evaluated.

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 time sport fishery. Since then, annual releases of summer steelhead have remained fairly consistent at approximately 75,000 smolts (Figure 9). As stated previously, 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 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) 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 out of concern for those out-of-basin ESA-listed strays. The trapping of marked hatchery steelhead continued until 2007 when Marmot Dam was removed.

Summer steelhead are not indigenous to the Sandy River and so there is some risk 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 from December through February, it is during the month of February that the spawn timing of the summer steelhead and winter steelhead can overlap (Lewis 2013). Studies in other basins looking at genetic interaction between summer steelhead and natural-origin winter steelhead found only minimal genetic introgression due to the limited time that spawning overlaps (Leider et al. 1984; Kostow et al. 2003; Kostow and Zhou 2006). 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 will home to this location and in time to prevent overlap with winter steelhead.

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% (i.e., pHOS originating from all sources included the summer steelhead hatchery program) ODFW conducts 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% then the pHOS rate attributable to summer steelhead spawning naturally would also be less than 5%.

Precise estimation of pHOS for summer steelhead is difficult because summer and winter steelhead redds (i.e., salmonid nests with eggs) 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, 2 steelhead were observed in February during the 2010 winter steelhead spawning survey, one with an ad-clip and one unclipped, yielding a pHOS estimate for February of 50% (0.5). During that survey season, a total 231 redds were observed, 2 of them in February. The summer steelhead pHOS estimates for that survey season was thus 0.43% (0.5 x 2/231). In 2012, the pHOS for winter steelhead was zero in February and as a result, the pHOS for summer steelhead was also zero. In 2013, the overall pHOS for winter steelhead was estimated to be 6.4%, but in February all 15 steelhead observed were unclipped, resulting in a summer steelhead pHOS estimate of 0% (Brown 2014).

In 2012, the pHOS for winter steelhead was zero and as a result, the pHOS for summer steelhead was also zero. This continues to be the best method to estimate pHOS for summer steelhead, though as described above for winter steelhead, the small sample size for these years limits our confidence in the final estimates. Our 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%. During February 2013, there were 15 steelhead that were observed and they all were determined to be unclipped, for a pHOS rate of 0%, as a result, the proportion of the natural spawning steelhead in 2013 that were summer steelhead was zero (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. Returning hatchery summer steelhead that did spawn naturally would have produced juveniles that potentially, 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 2). Following the best management practice of acclimating and releasing hatchery summer steelhead at the Sandy Hatchery so that they are more likely to return to the hatchery later as adults is likely to contribute to achieving the pHOS goal of <5% for out-of-basin stocks from 1999 Jeopardy Opinion RPA (NMFS 1999).

VSP Analysis

Below we look at all of the effects of all the actions, described above, that have occurred since 2004 (the last year of data used to evaluate the VSP parameters for the Sandy River populations by McElhany et al. (2007)), to evaluate if these changes have affected the scoring of the

individual VSP parameters and their constituent elements, and thus to provide a baseline for comparing effects of the Proposed Action.

Spring Chinook Salmon
Applying the VSP elements used by McElhany et al. (2007), abundance has increased since 2004 (McElhany et al. (2007)), and possibly productivity as well after terminating the release of Clackamas Hatchery spring Chinook salmon into the Sandy River, following the removal of hatchery adults at Marmot Dam, and after the removal of Marmot Dam and its associated impacts. 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 open 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).

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 (2005-2013, Table 2), 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 Section 2.4.1.2). With the exclusion of natural-origin adults in broodyears 2011, 2012, and 2013, PNI is expected to decline substantially to a low point in 2016 when pNOB is zero for almost all of the returning broodyears. The impacts of hatchery introgression due to releases from outside the population are expected to decline with the complete elimination of the Clackamas Hatchery spring Chinook salmon program 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 status of the Sandy River spring Chinook salmon population is expected to improve after the habitat and hatchery actions described above have time to reach their full affect. In the interim, the population remains at moderate risk of extinction.

Coho Salmon
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 increased for the

cohort that was previously identified as being substantially lower, while one cohort has remained about the same, and one cohort has declined (Table 2). Productivity is thought to be increasing after 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. In the past, this 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, adult unmarked 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. 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% since the removal of Marmot Dam. The mean pHOS for this period was 7.12% and this would not change the score for this element from what was provided by McElhany et al. (2007). 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 it probably would not change the score for the habitat diversity element, 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 9).

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 (2010) determined that the productivity of the natural population has declined relative to the 2007 review and their revision indicated that the Sandy River coho salmon population was at a high risk of extinction (low persistence score)(Figure 6). 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 potential benefits from the reduction in hatchery coho salmon production.

Winter Steelhead

Applying the VSP elements used by McElhany et al. (2007), the abundance and productivity parameter score was less than one 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. 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 and great care should be taken before comparing these numbers with more recent data that provides estimates for natural-origin and hatchery returns separately (see Figure 10 in McElhany et al. (2007)). The continuation of intensive monitoring will 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. In the past, the weir completely blocked passage at the Sandy Hatchery, such that natural-origin winter steelhead could not utilize the habitat in Cedar Creek above the 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 assinged 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 will remain at a moderate to high persistence level.

When looking at hatchery impacts 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. NMFS expects that this element will continue to improve since Big Creek stock winter steelhead are not being released and natural-origin winter steelhead have been used in the broodstock where pNOB ranged from 18% to 100%.. 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 1.0 in 2011, and 2012 because pHOS was estimated to be zero in those years (see the comment below about confidence in pHOS estimates for 2010-2012). 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), though it should be reiterated that we have very low confidence in the pHOS estimates for return years 2010, 2011, and 2012. The PNI metric will not be applicable for return years 2015-2017 because adults returning in those years are from broodstock made up of only hatchery winter steelhead. It is expected that the absence of natural-origin adults in the broodstock will have only minor effects on the diversity element as long as pHOS remains below 10%.

As described above, pHOS has been highly variable since the removal of Marmot Dam averaging 8.7% during the period. The synthetic approach score of 3.0 assigned by McElhany et al. (2007) would not be expected to change because pHOS appears to remain low. 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 it probably would not change the score for the habitat diversity element. Overall the diversity parameter score of 2.5 assigned in 2007 should not change for now, but the score is expected to increase as improvements in habitat and hatchery practices take effect.

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). This, along with the continued low pHOS for summer steelhead, is expected to minimize any hatchery impacts on the winter steelhead diversity parameter related to the release of out-of-basin stocks.

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 2010). 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.

Fisheries

The Sandy River spring Chinook salmon program supports a substantial recreational fishery in the lower Sandy River (Taylor 1998). Beginning in 2002, harvest of spring Chinook salmon in the Sandy River Basin was limited to adipose fin-clipped fish of hatchery origin. All natural-origin fish are required to be released. By implementing a selective fishery for hatchery spring Chinook salmon in the Sandy River, impact rates are estimated to have been reduced by over 85%, from around 40% to a range of 4.2 to 6.1% (ODFW 2003b; 2003c). ODFW completed a quantitative Population Viability Analysis (PVA) that indicated the maximum rate of fishery impacts on the Sandy River spring Chinook salmon population was 30%. Above this level there are increasing risks to survival and recovery of the natural population. The risk assessment results are conservative because the PVA was based on worse-case productivity assumptions (ODFW 2003b). The expected freshwater harvest rate of 8.6%, a combination of Sandy River harvest and mainstem Columbia River harvest, will not approach the maximum impact rate of 30%. The Sandy River is closed to Chinook salmon fishing after October 31 to protect naturally spawning fall Chinook salmon.

Mark selective fisheries for winter steelhead were first implemented in 1992 and have greatly reduced impacts on natural-origin winter steelhead in the Sandy River. The rate of harvest impacts are estimated to be between 2.0 and 2.5%, based on a post release mortality of 5% and a maximum fishery encounter rate of 40% (ODFW 2003c). To harvest hatchery summer steelhead and reduce pHOS, both marked and unmarked steelhead can be retained in tributaries upstream of the mouth of the Salmon River from July 1 to August 1. Only artificial flies and lures can be used in this fishery to limit impacts on juvenile salmonids. Mark selective fisheries for hatchery coho salmon were implemented in 1999 when marked hatchery coho salmon first began returning to the river. The area above Marmot Dam was closed to coho fishing, but since removal of the dam, the Sandy River up to the mouth of the Salmon River is open year around to the harvest of hatchery coho salmon. Based on observed encounter rates and post release mortality rates, annual impact rates on natural-origin coho salmon in the Sandy River are estimated to be less than 3% for the recreational fishery (ODFW 2005a).

To protect juvenile salmon and steelhead, trout angling in streams throughout the basin is limited to a late May through October time period. Most catchable juvenile salmon and steelhead leave the Action Area before the end of May. All angling for trout in the Sandy Basin is catch and release only and restricted to artificial flies and lures (no bait). Hatchery trout are no longer released into the basin. As a result impacts from trout fisheries are low.

As described above under the diversity element for anthropogenic mortality, harvest impacts have declined substantially from levels observed prior to the late 1990s, and these low levels of impact are expected to continue into the future. As a result, fisheries are not expected to affect the VSP diversity parameter for ESA-listed salmon and steelhead in the Sandy River.

Summary

As described in the sections above, the status of the three ESA-listed populations in the Sandy River range from moderate risk of extinction (spring Chinook salmon) to very high risk (coho salmon) and the goal for all three populations is to be at a low risk or at very low risk of

extinction (the latter is for winter steelhead) (NMFS 2013c). Some of the factors that contributed to the present VSP status for ESA-listed species, as described above and in more detail in the LCR Recovery Plan (NMFS 2013c), continue to impact natural-origin populations in the Sandy River Basin. On the other hand, there is clear evidence that many of the factors are being or have been remedied through hatchery actions, dam removal, and habitat improvements, and these actions are likely, based on the best available information, to result in an improving trend in those viability parameters that define the status of the ESA-listed salmon and steelhead. NMFS has developed this environmental baseline, as described above, to provide a reference point for the analysis of effects of the Proposed Action on the ESA-listed species.

Information relevant to the environmental baseline is also discussed in detail in Chapter 5 of the Supplemental Comprehensive Analysis (SCA), which in turn cross-references back to the related 2008 FCRPS biological opinion (NMFS 2008g; 2008i). Chapter 5 of the SCA (NMFS 2008i) and related portions of the FCRPS Opinion provide an analysis of the effects of past and ongoing human and natural factors on the current status of the species, their habitats, and their ecosystems, within the entire Columbia River Basin. In addition, chapter 5 of the SCA and related portions of the FCRPS Opinion evaluate the effects of those ongoing actions on designated critical habitat in the same area. Those portions of chapter 5 of the SCA, and the environmental baseline section of the FCRPS Opinion, that deal with effects in the Action Area (as described in Section 1.4, above) are hereby incorporated by reference. In addition, the environmental baseline for this opinion includes the impacts of the proposed action described in the FCRPS and Reclamation biological opinions (NMFS 2008g).

2.4. Effects on ESA Protected Species and on Designated Critical Habitat

This section describes the effects of the Proposed Action, independent of the Environmental Baseline and Cumulative Effects. The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized first in Section 2.4.1 and then application of the methodology and analysis of the Proposed Action itself follows in Section 2.4.2. The "effects of the action" means the direct and indirect effects of the action on individuals within the population and how these may affect the VSP parameters for the populations that make up the species and on designated critical habitat, together with the effects of other activities that are interrelated or interdependent, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the Proposed Action and are later in time, but still are reasonably certain to occur. Effects of the Proposed Action that are expected to occur later in time (i.e., just after timeframe of the Proposed Action) are included in the analysis in this opinion to the extent they can be meaningfully evaluated. In Section 2.6, the Proposed Action, the status of ESA-protected species and designated critical habitat, the Environmental Baseline, and the Cumulative Effects of future state and private activities within the Action Area that are reasonably certain to occur are analyzed comprehensively to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA protected species or result in the destruction or adverse modification of their designated critical habitat.

2.4.1. Factors That are Considered When Analyzing Hatchery Effects

The NMFS has substantial experience with hatchery programs and has developed and published a series of guidance documents for designing and evaluating hatchery programs following best

available science. These documents are available upon request from the NMFS SFD in Portland, Oregon. "Pacific Salmon and Artificial Propagation under the Endangered Species Act" (Hard et al. 1992) was published shortly following the first ESA-listings of Pacific salmon on the West Coast and it includes information and guidance that is still relevant today. In 2000, NMFS published "Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units" (McElhany et al. 2000) and then followed that with a "Salmonid Hatchery Inventory and Effects Evaluation Report" for hatchery programs up and down the West Coast (NMFS 2004b). In 2005, NMFS published a policy that provided greater clarification and further direction on how it analyzes hatchery effects and conducts extinction risk assessments (NMFS 2005b). NMFS then updated its inventory and effects evaluation report for hatchery programs on the West Coast (Jones 2006) and followed that with "Artificial Propagation for Pacific Salmon: Assessing Benefits and Risks & Recommendations for Operating Hatchery Programs Consistent with Conservation and Sustainable Fisheries Mandates" (NMFS 2008b). More recently, NMFS published its biological analysis and final determination for the harvest of Puget Sound Chinook salmon, which included discussion on the role and effects of hatchery programs (NMFS 2011c).

A key factor in analyzing a hatchery program for its effects, positive and negative, on the status of salmon and steelhead are 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 will be included in any listing of the ESU" (NMFS 2005b). NMFS monitors hatchery practices for whether they promote the conservation of genetic resources included in an ESU or steelhead DPS and updates the status of genetic resources residing in hatchery programs every five 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 speaking, 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, then NMFS refers to the program as "isolated" (also sometimes referred to as a "segregated" program). Generally speaking, isolated 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. They 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, different ocean migrations and spatial and temporal spawning distribution, compared to the native population (extant in the wild, in a hatchery, or both). For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany et al. 2000). NMFS defines population performance measures in terms of natural-origin fish and four key parameters or attributes: abundance, productivity, spatial structure, and diversity and then relates effects of the Proposed Action at the population scale to the MPG level and ultimately to the survival and recovery of an entire ESU or DPS (Figure 1).

"Because of the potential for circumventing the high rates of early mortality typically experienced in the wild, artificial propagation may be useful in the recovery of listed salmon species. However, artificial propagation entails risks as well as opportunities for salmon conservation" (Hard et al. 1992). A Proposed Action is analyzed for effects, positive and negative, on the attributes that define population viability, including abundance, productivity, 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 2005b). 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 2005b). NMFS also analyzes and takes into account the effects of hatchery facilities, for example, weirs and water diversions – on each VSP attribute and on designated critical habitat.

NMFS' analysis of the Proposed Action is in terms of effects it would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information 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 Section 2.4.2), which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (Section 2.6).

The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 7. Generally speaking, effects range from beneficial to negative for programs that use local fish[15] for hatchery broodstock and from negligible to negative when a program does not use local fish for broodstock[16]. 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 is particularly interested in how effective the program will be at isolating hatchery fish and avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. The range in effects 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.

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

[15] 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).
[16] Exceptions include restoring extirpated populations and gene banks.

Analysis of an HGMP or Proposed Action 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) ME&R 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 analysis assigns an effect for each factor from the following categories. The categories are:

(1) positive or beneficial effect on population viability,
(2) negligible effect on population viability, and
(3) negative effect on population viability.

Table 7. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs. The range in effects are refined and narrowed after the circumstances and conditions that are unique to individual hatchery programs are accounted for.

Natural population viability parameter	Hatchery broodstock originate from the local population and are included in the ESU or DPS	Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS
Productivity	**Positive to negative effect** Hatcheries are unlikely to benefit productivity except in cases where the natural population's small size is, in itself, a predominant factor limiting population growth (i.e., productivity) (NMFS 2004b).	**Negligible to negative effect** This 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 closer to a negligible affect).
Diversity	**Positive to negative effect** 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.	**Negligible to negative effect** This 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 closer to a negligible affect).
Abundance	**Positive to negative effect** 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).	**Negligible to negative effect** This is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation the closer to a negligible affect), handling, ME&R[17] and facility operation, maintenance and construction effects.
Spatial Structure	**Positive to negative effect** Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. "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).	**Negligible to negative effect** This 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 closer to a negligible affect).

[17] Monitoring, Evaluation and Research

"The effects of hatchery fish on the status of an ESU will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery within the ESU affect each of the attributes" (NMFS 2005b). The category of affect assigned is based on an analysis of each factor weighed against the affected population(s) current risk level for abundance, productivity, spatial structure and diversity, 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.

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

This factor considers the risk to a natural population from the removal of natural-origin fish for hatchery broodstock. The level of effect for this factor ranges from neutral or negligible to negative.

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 physical process of collecting hatchery broodstock and the effect of the process on ESA-listed species is considered under Factor 2.

2.4.1.2. 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. The level of effect for this factor ranges from positive to negative.

There are two aspects to this part of the analysis: genetic effects and ecological effects. NMFS generally views genetic effects as detrimental because at this time, based on the weight of available scientific information, we believe that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations. Hatchery fish 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 2011c).

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

Within-population genetic diversity is a general term for the quantity, variety and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size (N_e), 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.

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

Inbreeding depression, another N_e-related phenomenon, is caused by the mating of closely related individuals (e.g., sibs, half-sibs, cousins). The smaller the population, the more likely

spawners will be related. Related individuals are likely to contain similar genetic material, and the resulting offspring may then have reduced survival because they are less variable genetically or have double doses of deleterious mutations. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.

Outbreeding effects are caused by gene flow from other populations. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993; 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 2007), 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)[18] 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

[18] It is important to reiterate that as NMFS analyzes them, outbreeding effects are a risk only when the hatchery fish are from a different population than the naturally produced fish. If they are from the same population, then the risk is from hatchery-influenced selection. Non-native hatchery fish may also contribute to hatchery-influenced selection.

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 – one to two 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 especially well-publicized steelhead study (Araki et al. 2007; Araki et al. 2008), showed dramatic fitness declines in the progeny of naturally spawning Hood River hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies.

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery-origin and natural-origin fish (e.g.,Berntson et al. 2011; Theriault et al. 2011; Ford et al. 2012; Hess et al. 2012b). All have shown that generally hatchery-origin fish have lower reproductive success, though the differences have not always been statistically significant and in some years in some studies the opposite is true. Lowered reproductive success of hatchery-origin fish in these studies is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection,

studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date only the Hood River steelhead (Araki et al. 2007; Christie et al. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported multiple-generation effects.

Critical information for analysis of hatchery-influenced selection includes the number, location and timing of naturally spawning hatchery fish, the estimated level of interbreeding between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way.

Critical information for analysis of hatchery-influenced selection includes the number, location and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish[19]. The Interior Columbia Technical Recovery Team (ICTRT 2007) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS) (Figure 10).

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 isolated 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 the proportion of natural-origin fish in the broodstock (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 their guidelines are a pHOS of no greater than 5% for isolated programs or a pHOS no greater than 30% and PNI of at least 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 isolated 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.

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

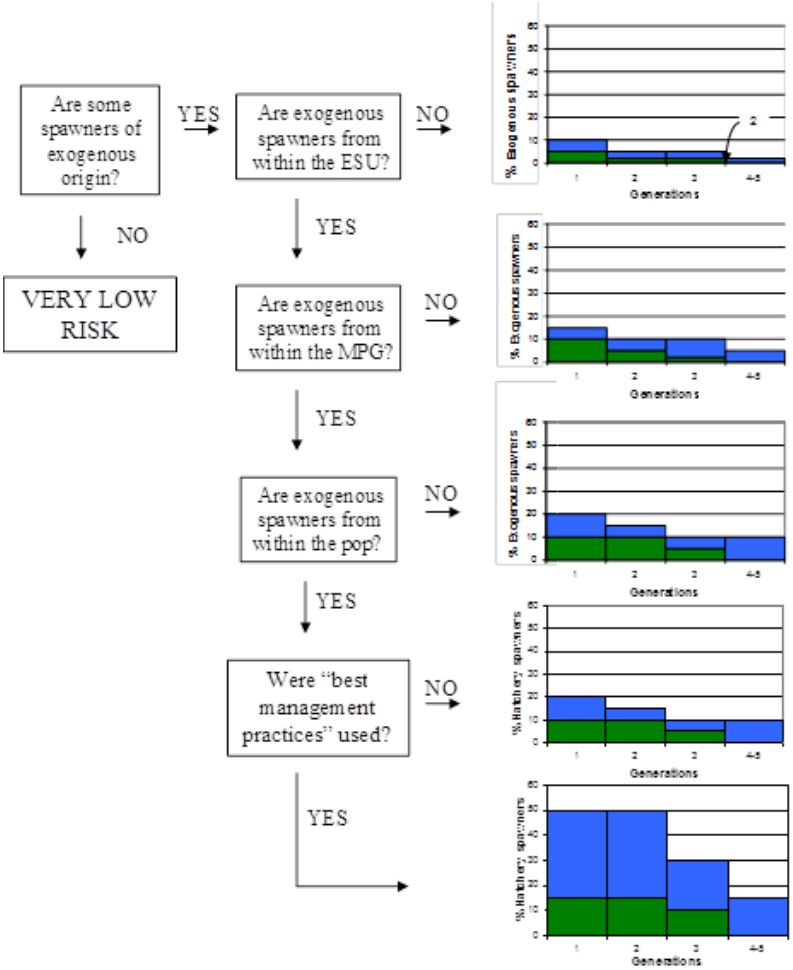

Figure 10**.** ICTRT (2007) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Green (darkest) areas indicate low risk combinations of duration and proportion of spawners, blue (intermediate areas indicate moderate risk areas and white areas and areas outside the graphed range indicate high risk). Exogenous fish are considered to be all fish hatchery origin, and non-normative strays of natural origin.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5%. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity". They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However,

they did state that PNI should exceed 50% in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5%, even approaching 100% at times. They also recommended for conservation programs that pNOB approach 100%, but pNOB levels should not be so high they pose demographic risk to the natural population.

Discussions involving pHOS can be problematic due to variation in its definition. Most commonly the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report, equating it with "the proportion of the natural spawning population that is made up of hatchery fish" in the Conclusion, Principles and Recommendations section (HSRG 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*. Despite these inconsistencies, their overall usage of pHOS indicates an intent to use pHOS as a surrogate measure of gene flow potential. This is demonstrated very well in the fitness effects appendix (HSRG 2009c, appendix A1), in which pHOS is substituted for a gene flow variable in the equations used to develop the criteria. NMFS concludes that if pHOS guidelines are used in analysis of hatchery effects, the pHOS metric should as much as possible represent gene flow potential, therefore pHOS should be considered the *effective* proportion of hatchery-origin spawners in the natural spawning population. Thus, the "census" pHOS should be adjusted as appropriate for RRS or other factors limiting the success of hatchery-origin spawners to yield a value closer to the true expected gene flow, or "effective pHOS". This adjustment should not be done indiscriminately, however. As discussed above, enough research has been done to conclude that hatchery-origin spawners are generally less successful in the wild than natural spawners, but unless population-specific information is available, assumptions about effectiveness should be conservative.

A simple analysis of the expected proportions of mating types provides additional perspective on pHOS. Figure 11 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly[20]. For example, the vertical line on the diagram marks the situation at a census pHOS level of 10%. At this level, expectations are that 81% of the matings will be NxN, 18% will be NxH, and 1% will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10% will have an 81% chance of having two natural-origin parents, etc.

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

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

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

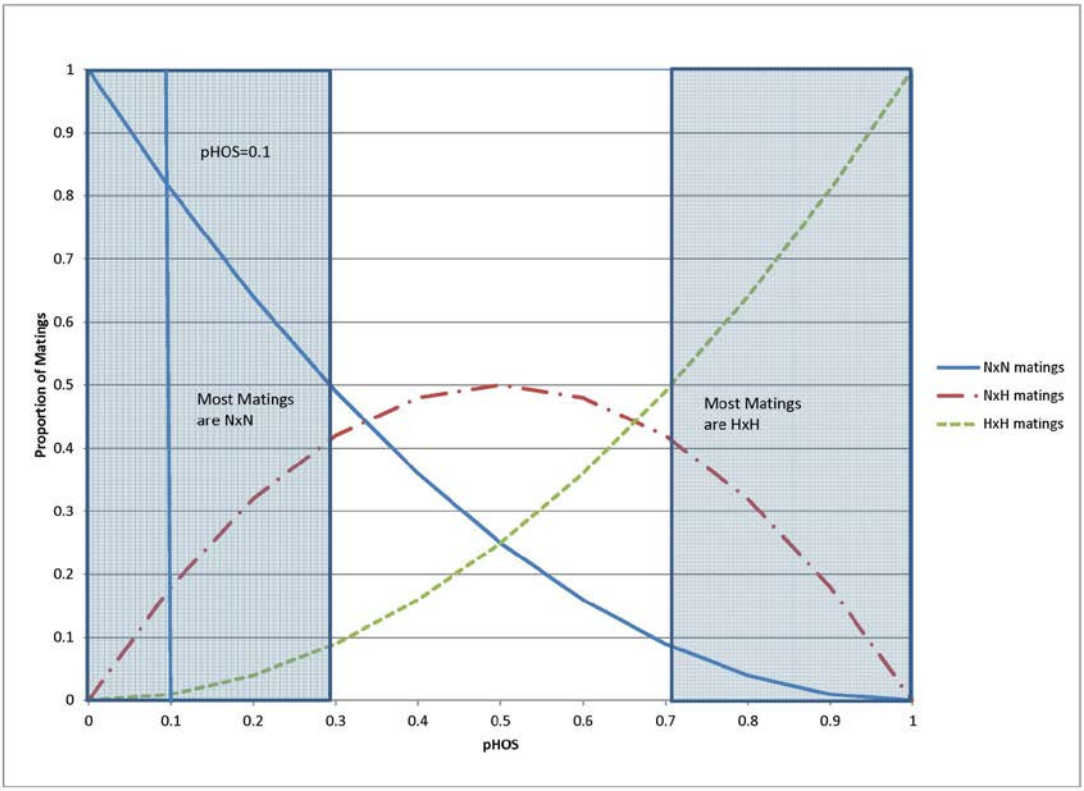

Figure 11. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS) (NxN – natural-origin x natural-origin; NxH – natural-origin x hatchery; HXH – hatchery x hatchery).

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 will 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 indicated 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 more 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 will 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 isolated from primary spawning areas. Factors 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 will hold in that area prior to their removal and/or harvest in fisheries.

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 speaking, the more a hatchery program accesses the run at large for hatchery broodstock – that is, the more fish that are handled or delayed during migration – the greater the negative effect on natural-origin and hatchery-origin fish that are intended to spawn naturally and to 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.

NMFS also analyzes the effects of structures, either temporary or permanent, that are used to collect hatchery broodstock. NMFS analyzes effects on fish, juveniles and adults, from encounters with these structures and effects on habitat conditions that support and promote viable salmonid populations. NMFS wants to know, for example, if the spatial structure, productivity, or abundance of a natural population is affected when fish encounter a structure used for broodstock collection, usually a weir or ladder. NMFS also analyzes changes to riparian habitat, channel morphology and habitat complexity, water flows, and in-stream substrates attributable to the construction/installation, operation, and maintenance of these structures. NMFS also analyzes the effects of structures, either temporary or permanent, that are used to remove hatchery fish from the river or stream and prevent them from spawning naturally, effects on fish, juveniles and adults, from encounters with these structures and effects on habitat conditions that support and promote viable salmonid populations.

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

NMFS also analyzes the potential for competition, predation, and premature emigration when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas. The level of effect for this factor ranges from neutral or negligible to negative.

Generally speaking, competition and a corresponding reduction in productivity and survival may result from direct interactions when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish or through indirect means, when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (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 them more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter naturally produced salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on naturally produced fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

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.

En masse hatchery salmon smolt releases may cause displacement of rearing naturally produced juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration (Pearsons et al. 1994). Pearsons et al. (1994) reported small-scale displacement of juvenile 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,[21] 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.

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. Hatchery fish released at a later stage, so they are more likely to emigrate quickly to the ocean, can 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

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

predation is greatest when natural populations of salmon and steelhead are at low abundance and when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

SIWG (1984) rated most risks associated with predation as unknown, because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead, and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 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 fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat, predominately) than their hatchery counterparts.

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

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (Pearsons and Fritts 1999; HSRG 2004) but other studies have concluded that salmonid predators prey on fish 1/3 or less their length (Horner 1978; Hillman and Mullan 1989; Beauchamp 1990; Cannamela 1992; CBFWA 1996). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Sosiak et al. 1979; Bachman 1984; Olla et al. 1998).

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.

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

Based on a review of the scientific literature, NMFS' conclusion is that the influence of density-dependent interactions on the growth and survival of salmon and steelhead is likely small compared with the effects of large-scale and regional environmental conditions 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 thing is true for mainstem rivers and estuaries. NMFS will watch for new research to discern and to measure the frequency, the intensity, and the resulting effect of density-dependent interactions between hatchery and natural-origin fish. In the meantime, NMFS will monitor emerging science and information and will consider that re-initiation of Section 7 consultation is required in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4.1.5. Factor 5. Research, monitoring, and evaluation that exists because of the hatchery program

NMFS also analyzes proposed ME&R for its effects on listed species and on designated critical habitat. The level of effect for this factor ranges from positive to negative.

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

Hatchery actions also must be assessed for masking effects. For these purposes, masking is when hatchery fish included in the Proposed Action mix with and are not identifiable from other fish. The effect of masking is that it undermines and confuses 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.

2.4.1.6. 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. Here, NMFS analyzes changes to riparian habitat, channel morphology and habitat complexity, in-stream 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. The level of effect for this factor ranges from neutral or negligible to negative.

2.4.1.7. Factor 7. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis of HGMP effects in a Section 7 consultation. One is where there are fisheries that 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. The level of effect for this factor ranges from neutral or negligible to negative.

"Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty obligations with regard to harvest of some Pacific salmon and steelhead populations. For ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under Section 4(d) of the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and recovery needs of the ESU, in accordance with approved harvest plans" (NMFS 2005b). In any event, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.

2.4.2. Effects of the Proposed Action

Analysis of the Proposed Action identified that within the Action Area, ESA-listed species are likely to be negatively affected and take will occur as a result of five of the seven factors described in Section 2.4.1. They are: the removal of natural-origin adults for broodstock; 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; hatchery fish and

progeny of naturally spawning hatchery fish in juvenile rearing areas (i.e., competition, and predation); ME&R that exists because of the hatchery program; and operation and maintenance of the hatchery facilities. No factors were found to benefit ESA-listed species (Table 8). An overview of the analysis is described below.

Table 8. A summary of the effects of the Sandy River hatchery programs on ESA-listed Salmon and Steelhead and on designated critical habitat. The framework NMFS followed for analyzing effects of the hatchery programs is described in Section 2.4.1 of this opinion.

		Analysis of Effects for each Factor by Program			
Factor	**Range in Potential Effects for this Factor**	**Sandy River Spring Chinook Salmon Hatchery Program**	**Sandy River Coho Salmon Hatchery Program**	**Sandy River Winter Steelhead Hatchery Program**	**Sandy River Summer Steelhead Hatchery Program**
The hatchery program does or does remove fish from the natural population and use them for broodstock	Negligible to negative effect	**Negative** This is a negative effect but it is low since the hatchery will not remove in any single year, more than 2% of the returning natural-origin Sandy River spring Chinook salmon including zero females.	**Negligible** The effect for this factor is negligible because natural-origin ESA-listed fish are not removed from the population for hatchery broodstock.	**Negative** This is a negative effect but it is low since the hatchery will not remove in any single year more than 2% of the returning natural-origin Sandy River winter steelhead including zero females.	**Negligible** No ESA-listed fish are used for hatchery broodstock.
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	Positive to negative effect	**Negative** pHOS, the surrogate used here for gene-flow, spiked in 2010 but has been on a downward trend and has declined to below 10%. At this level and considering the origin of the hatchery broodstock and the duration of the hatchery program, hatchery spring Chinook salmon on the spawning grounds pose a low risk to the natural-origin Sandy River spring Chinook salmon population.	**Negative** The pHOS goal for this program is <5% and is very conservative since hatchery coho salmon in the Sandy River are integrated with the natural population and included in the LCR Coho Salmon ESU. Under these circumstances, hatchery coho salmon on the spawning grounds pose a low risk to the natural-origin Sandy River coho salmon population. Weir operations do not	**Negative** Data for estimating winter steelhead pHOS is extremely limited, but based on expanded surveys in 2013, pHOS for winter steelhead is <10%. At this level and considering the origin of the hatchery broodstock and the duration of the hatchery program, hatchery winter steelhead on the spawning grounds pose a low risk to the natural-origin Sandy River winter steelhead population. Continued	**Negative** Data for estimating summer steelhead pHOS and genetic effects is extremely limited. This program is expected to limit summer steelhead pHOS to <5% and at that level, it poses a low risk to the natural-origin Sandy River winter steelhead population. Improved monitoring and evaluation will provide more reliable estimates for summer steelhead pHOS.

		Analysis of Effects for each Factor by Program			
Factor	**Range in Potential Effects for this Factor**	**Sandy River Spring Chinook Salmon Hatchery Program**	**Sandy River Coho Salmon Hatchery Program**	**Sandy River Winter Steelhead Hatchery Program**	**Sandy River Summer Steelhead Hatchery Program**
		The level of negative effects from fish encountering the weirs appears to be minimal, based on recent monitoring and evaluation of the weirs, but additional monitoring and reporting is necessary.	appear to be a threat to coho salmon viability. Natural-origin coho salmon are handled at the Sandy Hatchery during broodstock collection activities. All unmarked coho salmon are passed upstream of the hatchery to spawn naturally.	expanded monitoring is necessary to provide valid estimates for pHOS. Natural-origin winter steelhead will be handled at the Sandy Hatchery during broodstock collection activities. All unmarked winter steelhead collected at the Sandy Hatchery will be passed upstream of the hatchery to spawn naturally. A proportion of the natural-origin population will be collected for broodstock using hook and line. This program is designed to serve as a safety net and to conserve natural-origin winter steelhead in Cedar Creek.	Natural-origin winter steelhead will be handled at the Sandy Hatchery during adult collection activities.
Hatchery fish and the progeny of naturally	Negligible to negative effect	**Negligible effect** The potential for competition and	**Negligible effect** The potential for competition and	**Negligible effect** The potential for competition and	**Negligible effect** The potential for competition and

		Analysis of Effects for each Factor by Program			
Factor	**Range in Potential Effects for this Factor**	**Sandy River Spring Chinook Salmon Hatchery Program**	**Sandy River Coho Salmon Hatchery Program**	**Sandy River Winter Steelhead Hatchery Program**	**Sandy River Summer Steelhead Hatchery Program**
spawning hatchery fish in juvenile rearing areas		predation poses a low risk to fish from ESA-listed natural populations. Juvenile hatchery spring Chinook salmon and the progeny of naturally spawning hatchery spring Chinook salmon co-occur with ESA-listed natural-origin salmon and steelhead in the lower Bull Run River, in tributaries to the Sandy River, and in the mainstem Sandy River However, there are no data and there is no evidence to indicate that competition or predation poses any meaningful risk to ESA-listed natural populations in the Sandy Basin.	predation poses a low risk to fish from ESA-listed natural populations. Juvenile hatchery coho salmon and the progeny of naturally spawning hatchery coho salmon co-occur with ESA-listed natural-origin salmon and steelhead in the lower Bull Run River, in tributaries to the Sandy River, and in the mainstem Sandy River However, there are no data and there is no evidence to indicate that competition or predation poses any meaningful risk to ESA-listed natural populations in the Sandy Basin.	predation poses a low risk to fish from ESA-listed natural populations. Juvenile hatchery winter steelhead and the progeny of naturally spawning hatchery winter steelhead co-occur with ESA-listed natural-origin salmon and steelhead in the lower Bull Run River, in tributaries to the Sandy River, and in the mainstem Sandy River However, there are no data and there is no evidence to indicate that competition or predation poses any meaningful risk to ESA-listed natural populations in the Sandy Basin.	predation poses a low risk to fish from ESA-listed natural populations. Juvenile hatchery summer steelhead and the progeny of naturally spawning hatchery summer steelhead co-occur with ESA-listed natural-origin salmon and steelhead in the lower Bull Run River, in tributaries to the Sandy River, and in the mainstem Sandy River However, there are no data and there is no evidence to indicate that competition or predation poses any meaningful risk to ESA-listed natural populations in the Sandy Basin.

		Analysis of Effects for each Factor by Program			
Factor	**Range in Potential Effects for this Factor**	**Sandy River Spring Chinook Salmon Hatchery Program**	**Sandy River Coho Salmon Hatchery Program**	**Sandy River Winter Steelhead Hatchery Program**	**Sandy River Summer Steelhead Hatchery Program**
Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean	Negligible to negative effect	**Negligible effect** Effects of the Proposed Action are not detectable. Available information does not show the level of hatchery production that leads to measureable competition, nor does it identify how and to what extent ESA-listed species would be disadvantaged. The conditions under which competitive interactions take place would not occur, and competitive advantages and disadvantages for different life-history stages, populations, ESUs and DPSs, and for hatchery and natural-origin fish are not detectable.	**Negligible effect** Effects of the Proposed Action are not detectable. Available information does not show the level of hatchery production that leads to measureable competition, nor does it identify how and to what extent ESA-listed species would be disadvantaged. The conditions under which competitive interactions take place would not occur, and competitive advantages and disadvantages for different life-history stages, populations, ESUs and DPSs, and for hatchery and natural-origin fish are not detectable.	**Negligible effect** Effects of the Proposed Action are not detectable. Available information does not show the level of hatchery production that leads to measureable competition, nor does it identify how and to what extent ESA-listed species would be disadvantaged. The conditions under which competitive interactions take place would not occur, and competitive advantages and disadvantages for different life-history stages, populations, ESUs and DPSs, and for hatchery and natural-origin fish are not detectable.	**Negligible effect** Effects of the Proposed Action are not detectable. Available information does not show the level of hatchery production that leads to measureable competition, nor does it identify how and to what extent ESA-listed species would be disadvantaged. The conditions under which competitive interactions take place would not occur, and competitive advantages and disadvantages for different life-history stages, populations, ESUs and DPSs, and for hatchery and natural-origin fish are not detectable.
ME&R that exists because of the hatchery program	Positive to negative effect	**Negative effect** Proposed ME&R activities (i.e., the collection, sampling, and tagging) will cause injury and death to ESA-	**Negative effect** Proposed ME&R activities (i.e., the trapping, sampling, and tagging) will cause injury and death to ESA-	**Negative effect** Proposed ME&R activities (i.e., the trapping, sampling, and tagging) will cause injury and death to ESA-	**Negative effect** Proposed ME&R activities (i.e., the collection, sampling, and tagging) will cause injury and death to ESA-

		Analysis of Effects for each Factor by Program			
Factor	**Range in Potential Effects for this Factor**	**Sandy River Spring Chinook Salmon Hatchery Program**	**Sandy River Coho Salmon Hatchery Program**	**Sandy River Winter Steelhead Hatchery Program**	**Sandy River Summer Steelhead Hatchery Program**
		listed salmon and steelhead juveniles. The full extent of this effect does not pose a serious risk to ESA-listed natural populations. Data collected during these activities are needed to evaluate the hatchery program to determine the effects on ESA-listed species.	listed salmon and steelhead. The full extent of this effect does not pose a serious risk to ESA-listed natural populations. Data collected during these activities are needed to evaluate the hatchery program to determine the effects on ESA-listed species.	listed salmon and steelhead. The full extent of this effect does not pose a serious risk to ESA-listed natural populations. Data collected during these activities are needed to evaluate the hatchery program to determine the effects on ESA-listed species.	listed salmon and steelhead. The full extent of this effect does not pose a serious risk to ESA-listed natural populations. Data collected during these activities are needed to evaluate the hatchery program to determine the effects on ESA-listed species.
Construction, operation, and maintenance of facilities that exist because of the hatchery program	Negligible to negative effect	**Negligible effect** Hatchery diversion screens protect juvenile fish from entrainment and injury and satisfy NMFS screen criteria. Operation of the facility is not expected to degrade water quality. Water is treated before it is returned to the river and the program has a current NPDES permit. Water withdrawal at the Sandy Hatchery is not expected to impact juvenile steelhead and	**Negligible effect** Hatchery diversion screens protect juvenile fish from entrainment and injury and satisfy NMFS screen criteria. Operation of the facility is not expected to degrade water quality. Water is treated before it is returned to the river and the program has a current NPDES permit. Water withdrawal at the Sandy Hatchery is not expected to impact juvenile steelhead and	**Negligible effect** Hatchery diversion screens protect juvenile fish from entrainment and injury and satisfy NMFS screen criteria. Operation of the facility is not expected to degrade water quality. Water is treated before it is returned to the river and the program has a current NPDES permit. Water withdrawal at the Sandy Hatchery is not expected to impact juvenile steelhead and	**Negligible effect** Hatchery diversion screens protect juvenile fish from entrainment and injury and satisfy NMFS screen criteria. Operation of the facility is not expected to degrade water quality. Water is treated before it is returned to the river and the program has a current NPDES permit. Water withdrawal at the Sandy Hatchery is not expected to impact juvenile steelhead and

		Analysis of Effects for each Factor by Program			
Factor	**Range in Potential Effects for this Factor**	**Sandy River Spring Chinook Salmon Hatchery Program**	**Sandy River Coho Salmon Hatchery Program**	**Sandy River Winter Steelhead Hatchery Program**	**Sandy River Summer Steelhead Hatchery Program**
		coho salmon spatial distribution in Cedar Creek during the period that spring Chinook salmon are reared at the hatchery because flows greatly exceed the water withdrawals. The intake for the Bull Run Acclimation pond is within the same pool as the pond out fall, and is operated for a short period in the spring and will not impact fish distribution. The peak surface water use at the Clackamas Hatchery when Sandy River adults are being held is less than 2% of the low flow period and affects a ¼ mile section of the Clackamas River, intake screens currently do not meet NMFS criteria, however impingement or entrainment risk is very	coho salmon spatial distribution in Cedar Creek during the period that coho salmon are reared at the hatchery because minimum flows are maintained in the section of Cedar Creek between the hatchery intake and outfall such that juvenile steelhead and coho salmon spatial distribution in Cedar Creek is not affected. The hatchery facility has a current NPDES permit, and effluent would be monitored to ensure compliance with permit requirements.	coho salmon spatial distribution in Cedar Creek during the period that winter steelhead are reared at the hatchery, because flows greatly exceed the water withdrawals. Oak Springs Hatchery uses spring water from sources that do not contain ESA-listed species. Bonneville Hatchery uses well water to rear steelhead. All hatchery facilities have current NPDES permits, and effluent would be monitored to ensure compliance with permit requirements.	coho salmon spatial distribution in Cedar Creek during the period that summer steelhead are reared at the hatchery because flows greatly exceed the water withdrawals. Bonneville Hatchery uses well water to rear steelhead. All hatchery facilities have current NPDES permits, and effluent would be monitored to ensure compliance with permit requirements.

		Analysis of Effects for each Factor by Program			
Factor	**Range in Potential Effects for this Factor**	**Sandy River Spring Chinook Salmon Hatchery Program**	**Sandy River Coho Salmon Hatchery Program**	**Sandy River Winter Steelhead Hatchery Program**	**Sandy River Summer Steelhead Hatchery Program**
		low. Oxbow Hatchery uses spring water and will not impact surface water or ESA-listed species. Cascade Hatchery diverts surface water from Eagle Creek reducing the flow over a 0.6 mile section during the summer. The Cascade Hatchery intake screens currently do not meet NMFS criteria. All hatchery facilities have current NPDES permits, and effluent would be monitored to ensure compliance with permit requirements.			
Fisheries that exist because of the hatchery program	Negligible to negative effect	**NA** Terminal fisheries targeting spring Chinook salmon produced by this program have been evaluated and authorized in a separate opinion (NMFS 2003c; 2008h)	**NA** Mainstem Columbia River fisheries targeting coho salmon produced by this program have been evaluated and authorized in a separate opinion (NMFS 2008h).	**NA** Terminal fisheries targeting winter steelhead produced by this program have been evaluated and authorized in a separate opinion (NMFS 2003c; 2008h)	**NA** Terminal fisheries targeting summer steelhead produced by this program have been evaluated and authorized in a separate opinion (NMFS 2003c; 2008h)

		Analysis of Effects for each Factor by Program			
Factor	**Range in Potential Effects for this Factor**	**Sandy River Spring Chinook Salmon Hatchery Program**	**Sandy River Coho Salmon Hatchery Program**	**Sandy River Winter Steelhead Hatchery Program**	**Sandy River Summer Steelhead Hatchery Program**
		and are therefore included in the environmental baseline.	A Fisheries Evaluation and Monitoring Plan for tributary coho fisheries has been submitted to NMFS for consultation. All of these fisheries are included in the environmental baseline.	and are therefore included in the environmental baseline.	and are therefore included in the environmental baseline.

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

Negative and negligible effects: The removal of natural origin spring Chinook salmon and winter steelhead would reduce the overall abundance of the populations, but the effects are expected to be negligible due to the use of only males, and live-spawning then releasing the fish back to the river.

Spring Chinook Salmon

The removal of less than 2% of the population is not expected to reduce survival and recovery of the natural-origin Sandy River spring Chinook salmon population.

Under the Proposed Action, ODFW proposes to collect up to 22 natural-origin male spring Chinook salmon to incorporate into the broodstock for the 132,000 smolt release level and up to 42 natural-origin male spring Chinook salmon at the 300,000 smolt release level. Note that the increase to a 300,000 smolt release level will not occur unless and until the pHOS goal of <10% has been achieved for four consecutive years. If the pHOS <10% for 4 consecutive years, ODFW will model potential increases to determine if a pHOS of <10% can be maintained. Any increase in production and smolt releases would occur in phases (e.g., increase to 180,000 then evaluate, and if pHOS remains <10% increase to 240,000 and then evaluate, etc.). Prior to any increase in production and associated increase in broodstock collection, ODFW must acquire NMFS' written concurrence.

To reduce demographic impacts, the natural-origin male spring Chinook salmon will be live-spawned and then returned to the Sandy River basin to potentially spawn again (Groot and Margolis 1991). No more than 2% of the natural-origin spring Chinook salmon returning to the Sandy River Basin will be used for hatchery broodstock. For example, if the annual return size is 650 spring Chinook salmon, no more than 13 males (2%) 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, and this represents only 1.3% of the natural-origin returns. The escapement of natural-origin spring Chinook salmon at the weirs will be monitored to ensure that the runsize is such that the collection of natural-origin male spring Chinook salmon will not exceed 2% of the final estimated natural-origin population.

The removal of male spring Chinook salmon would have a negligible effect 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 male natural-origin spring Chinook salmon handled at the Zigzag River and Salmon River weirs made up 59.5% of the natural-origin population above the weirs. Using these same numbers, the removal of 22 males to produce132,000 smolts would decrease the proportion of male spring Chinook salmon from 59.5% to 58.9%. The removal of 42 males to produce a release of 300,000 smolts, would decrease the proportion of natural-origin males on the spawning grounds to 58.3% from 59.5%.

Coho Salmon

The Sandy Hatchery coho salmon program does not remove natural-origin adults from the natural-origin Sandy River coho salmon population for hatchery broodstock.

Winter Steelhead

The removal of less than 2% of the Sandy River natural-origin winter steelhead population for hatchery broodstock purposes is not expected to reduce the survival and recovery of the Sandy River winter steelhead population.

Under the Proposed Action, ODFW would annually collect up to 26 natural-origin male winter steelhead for broodstock, but only if the natural-origin escapement is expected to exceed 650 adults. This level of escapement is 65% of the ESA delisting threshold for the Sandy River winter steelhead population (McElhany et al. 2006). Under no circumstances would no more than 2% of the natural-origin spawning population be removed for hatchery broodstock. The escapement of natural-origin winter steelhead will be monitored during winter steelhead spawning surveys to ensure that the winter steelhead escapement is such that broodstock collection will not exceed 2% of the natural-origin population. The removal of only male natural-origin fish would limit effects on the naturally spawning population. The 26 natural-origin adults would result in a pNOB of approximately 20%. 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% of the population for broodstock could be compared to an additional harvest of the Sandy River winter steelhead population. Winter steelhead spawning surveys will be used to monitor escapement of natural-origin winter steelhead to ensure that the runsize is not depressed such that the collection of the 26 natural-origin male winter steelhead will exceed 2% of the natural-origin 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 zero as long as mortality rates associated with harvest remained less than 30%. However, when mortality rates became greater than 40% 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 very rapid. Because the transition from low risk to high risk happens so rapidly there is little room for error (in either the model or measurement of mortality rates). To address this concern ODFW set a maximum fisheries impact limit of 20%, under the conservative assumption that this would provide a reasonable cushion for errors, even though the model results suggest that management under a 30% 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% of the natural-origin returns (ODFW 2003c). The less than 2% additional impact from the removal of 26 male natural-origin winter steelhead in addition to the impacts from the freshwater fisheries is expected to be less than 5% which is substantially below the maximum fisheries impact limit of 20%.

Summer Steelhead

For this factor, the summer steelhead hatchery program has no effect on Sandy River winter steelhead. Summer steelhead are not endemic to the Sandy River and therefore the broodstock is collected from other sources outside the Sandy River Basin. The summer steelhead broodstock for the Sandy River summer steelhead program are collected annually at the adult trap at Foster Dam in the Willamette River Basin.

2.4.2.2. 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

Negative effect: Genetic effects on ESA-listed salmon and steelhead populations in the Sandy River are a low risk and likely to occur from interactions on the spawning grounds between hatchery fish or progeny of naturally spawning hatchery fish and natural-origin salmon and steelhead.

Spring Chinook Salmon

The spring Chinook salmon hatchery program in its present form is relatively new, and the first adult fish from the program did not return to the Sandy River to spawn until 2006. As described above, the new program was recently derived from the natural-origin population, and incorporated natural-origin adults into the broodstock (at approximately 30% annually) until broodyears 2011, 2012, and 2013, when 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 not surprising that Sandy Hatchery spring Chinook salmon are not substantially diverged from the natural-origin spring Chinook salmon population and thus are included in the LCR Chinook salmon ESU and listed as a threatened species under the ESA (NMFS 2003b; 2004b; Jones 2011). For this reason, 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% in 2008, an then spiked at 77.1% in 2010. More recent surveys have shown a declining trend in pHOS for spring Chinook salmon (Table 6). The survey results for 2013 estimated a pHOS of 9.3%. These declines in pHOS correspond with actions implemented by the hatchery program 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.

PNI is a useful statistic for assessing the risk of hatchery-influenced selection in integrated programs. The HSRG (2009a) recommends a PNI[22] level of 0.67, or higher, for populations to reach a low risk or very low risk status (see detailed discussion in Section 2.4.1.2). As described above, PNI is a function of pHOS and pNOB (HSRG 2004; 2009a). 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 still in the range (PNI > 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. Because only hatchery adults were used for broodstock in 2011, 2012, and 2013 (i.e., pNOB was zero) PNI is expected to decline to lower levels for return years 2016 and 2017. If natural-origin adults are used for broodstock beginning with the 2014 broodyear, and with the expectation that pHOS would remain <10%, then PNI would exceed 0.66 in return year 2019, and remain above that level, consistent with the HSRG guidelines (HSRG 2009a).

When PNI is measurable (because the program incorporates natural-origin fish into the broodstock), as it is here, NMFS uses PNI in its analysis as a way of evaluating the genetic effects of a proposed hatchery program. An advantage from measuring and analyzing PNI is that it provides an indication of the extent to which natural selective forces are driving the natural population as opposed to hatchery-influence selection. In this case, NMFS will use both pHOS and PNI to measure the effects and performance the Sandy Hatchery spring Chinook salmon program.

NMFS supports the <10% pHOS goal that was developed by ODFW through the modeling of recovery scenarios in the ODFW Recovery Plan (ODFW 2010). 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 the <10% pHOS goal 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 2010). 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 <10% 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

[22] This metric was not considered in the previous biological opinion because natural-origin adults were not incorporated into the broodstock. Instead the primary management goal was to achieve the pHOS goal of <10% as a surrogate measure of limiting genetic introgression.

(high persistence), and under the TRT guidelines, in addition to meeting abundance and productivity targets for this designation, the average pHOS should be <10%.

Other analysis that supports the <10% pHOS goal for the Sandy River spring Chinook salmon population is the mating-frequency material in Section 2.4.1.2 and in Figure 11. Assuming random mating and complete temporal and spatial overlap, a pHOS level of 10% (0.1) should result in 81% of the matings being natural-origin x natural-origin, 18% being natural-origin x hatchery, and 1% being hatchery x hatchery. This high a proportion of natural-origin x natural-origin 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 natural-origin x natural-origin matings would be expected to be greater than 81% 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. 2014).

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 will 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 are working since pHOS was 9.3% in 2013.

As described in Section 2.4.1.2, 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 (at Marsh Road) 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. Hatchery fish that are acclimated and released at the Sandy Hatchery would tend to home back to the Sandy Hatchery because they imprinted on the scent of Cedar Creek water.

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. Compare this to 2013, when 444 hatchery spring Chinook salmon returned to the hatchery (McIntosh 2013b). Because of the variability in Cedar Creek flows during the time when hatchery spring Chinook salmon return, 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. In 2013, the first year of operation of the weir, 45 returning adult hatchery spring Chinook salmon were collected at the Bull Run weir, 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 2013b). As the number of adults returning from these releases increase, it is expected that fewer and fewer adults will be encountered at the weirs in the upper basin.

Another action taken to reduce the proportion of hatchery spring Chinook salmon spawning naturally was a reduction in the total number of juveniles released relative to baseline levels (Figure 9). 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 new hatchery program and beginning with the 2002 broodyear declined to 300,000 annually, and in 2013 the release was reduced further to 129,923 (McIntosh 2013b). The last hatchery adult from the previous 300,000 smolt release levels will continue to contribute to escapement until 2016. Hatchery adult surpluses, after harvest and broodstock collection, will decline as hatchery adults from the 132,000 smolt releases begin to return. Under the Proposed Action the annual production level will remain at 132,000 smolts but may increase up to 300,000 if monitoring and evaluation show that pHOS will remain <10%. All production will be released from the Bull Run acclimation pond.

Even though the full effect of all these actions will not be seen until at least 2015, pHOS has been trending down and was <10% in 2013 (Table 6). In 2011, when the operation of the weirs was tested for the first time, for part of the year[23], the pHOS declined from 73% to 61% for the primary spawning areas upstream of Marmot Dam (pHOS for the entire basin was estimated to be 66.5%) (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%. In 2013, the weir locations were adjusted and the Bull Run weir was operated for the first time, the resulting pHOS was 9.3%, based on an estimated runsize of 2,395 spring Chinook salmon adults (a combination of 2,172 natural-origin and 223 hatchery spring Chinook salmon) (McIntosh 2013b). This trend in pHOS and the magnitude in the trend, declining from over 77% to <10%, shows 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 is low.

We analyzed the use of only male natural-origin fish in the broodstock as a means of maintaining an integrated the spring Chinook salmon hatchery program and reducing hatchery-influenced selection risk. Using only males could pose a risk if the traits undergoing selection were sex-

[23] 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).

linked. No information of this type is available for Chinook salmon, but a considerable amount of research is currently underway in other species (especially *O. mykiss*) on the genetic basis of quantitative traits through QTL (quantitative trait loci) analysis, in which variation in traits is correlated with genetic markers on known chromosome regions. This is a technically complex body of literature that is too large to characterize here, but the sex chromosomes have been shown to be linked to important traits. Examples: upper thermal tolerance and fork length were associated with a sex-linked microsatellite marker (Perry et al. 2005), significant differences between the sexes were found at a condition factor locus located on the sex chromosome (Hecht et al. 2012), genetic correlations exist between QTLs and male age at maturation (Martyniuk et al. 2003), and early maturation in males and females may be under separate genetic control (Haidle et al. 2008). It is reasonable to assume that Chinook salmon would have roughly the same level of sex linkage as *O. mykiss.* Although the level of sex-linkage discovered thus far indicates that use of only one sex could result in a selection response different from one carried out on both sexes, it is not at all obvious at this point that this practice in the Sandy spring Chinook salmon program poses a substantial risk, especially when the single-sex part of the program involves only 20% of the broodstock and none of the natural spawners. However, NMFS' opinion on this may change as more research results become available.

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. 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 2010; 2011d).

ODFW will conduct spawning ground surveys to monitor effects on naturally spawning spring Chinook salmon to determine if there are impacts from handling, and changes in spawning distribution due to weir rejection. BMPs will 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 will 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 very

low levels, 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% (this is an absolute change, i.e., an increase of 10% to 15%, not an increase from 10% to 10.5%).

Under the Proposed Action, as many as 3,200 natural-origin spring Chinook salmon may be handled annually at various weir locations throughout the Sandy River Basin. It should be noted that handling, as referred to here, is expected to have very minimal effects, lethal and sub-lethal. The use of weirs in the Sandy River was first evaluated in 2011 when temporary weirs were installed for a short period in the Salmon River and in the Zigzag River (Schroeder et al. 2012). A total of 400 hatchery spring Chinook salmon were trapped and removed. A total of 185 natural-origin adults were passed upstream. This effort proved that weirs were more successful than previous collection methods such as seines, and hook and line, in capturing hatchery spring Chinook salmon. The removal of 400 hatchery adults in 2011 was estimated to reduce pHOS in those tributaries from 73% to 62% showing that weirs could be a useful tool in managing pHOS (Schroeder et al. 2013). No mortalities were observed during the operation of the weirs, and no substantial changes in spawning distribution or pre-spawning mortality were found (Schroeder et al. 2013).

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 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 modification 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 basin. Under normal conditions (i.e., in the absence of weirs) spawner distribution can vary year-to-year due to a whole 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 (20% versus 19% in 2012). In the lowest section of the Zigzag River the mean percentage of spawning by natural-origin spring Chinook salmon was 24% in 2002-2007, compared to 14% 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% 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 .57 river miles above the confluence with the mainstem Sandy River (Figure 12). 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. 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, ODFW may adjust the placement of the weirs to further improve their effectiveness and minimize impacts.

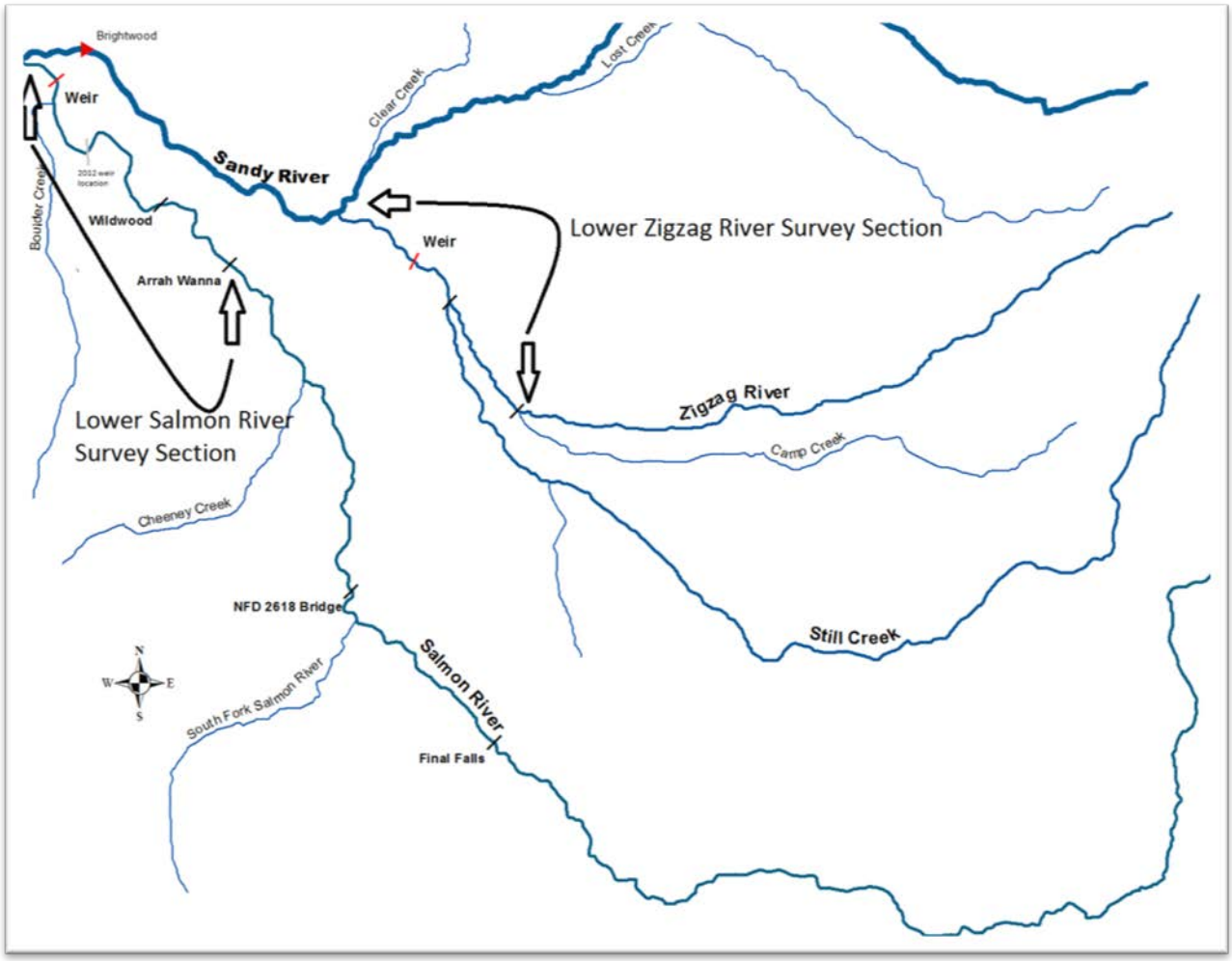

Figure 12. Upper Sandy River Basin showing location of weirs in 2013, and identifying spawning ground survey sections in the Zigzag River and Salmon River.

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% to 7% in the primary spawning areas upstream of the former Marmot Dam site (Whitman et al. 2014). 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 Trap on September 13, 2013, also did not have any signs of bodily damage (Lackey et al. 2013).

Weir Rejection

Weir operation may affect spawning distribution due to weir rejection (see Section 2.4.1.2). Because redd locations, observed during previous annual spawning surveys, were limited to

stream sections which do not correspond to current weir locations, ODFW compared 2013 redd distribution in three sections of the Salmon River, and three sections of the Zigzag River with average number of redds observed in those sections in 2002-2007 (Figure 12). Whitman et al. (2014) observed that the 2013 redd distribution in the Salmon and Zigzag rivers was similar to those observed in 2002-2007, suggesting that the weirs did not affect the distribution of naturally spawning salmon (Figure 13 and Figure 14). 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" which were added to these sections after the 2011 storm (Whitman et al. 2014). These storm water "diffusers" may have changed the scent of the water in this section affecting the homing of 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.

ODFW has identified three sections of the Salmon River and three sections of the Zigzag River (Figure 12) where they recorded the number of redds observed for each of those sections during the period 2002-2007 and determinations were made regarding the proportion of spring Chinook salmon redds in each section (Whitman et al. 2014). The Zigzag River and Salmon River are within the upper basin and encompass the majority of the natural spawning habitat for spring Chinook salmon in the Sandy River Basin. The weir locations are within the lower survey sections of each of these tributaries. Looking at the distribution of naturally spawning spring Chinook salmon for the period 2002-2007, ODFW determined the following:

- On average, 33.9% of the spring Chinook salmon spawning in the Salmon River spawned in the lower section (and 66.1% spawned in the upper two sections); and
- On average, 25.8% the spring Chinook salmon spawning in the Zigzag River spawned in the lower section (and 74.2% spawned in the upper two sections, includes Still Creek).

A shift in the spawning distribution relative to what was observed prior to the installation of the weirs may indicate that the weirs are affecting the natural spawning distribution of spring Chinook salmon in these tributaries. NMFS expects that up to a 10% absolute increase in the number of redds in the lower sections could occur just due to natural variability. An absolute increase of greater than 10% in the proportion of redds observed in the lower sections of these streams would indicate a substantial shift in spawning distribution. In years of high escapement (e.g., 2004) this would represent a shift of only 18 redds in the Salmon River and 5 redds on the Zigzag River (in an average year this would be 9 redds in the Salmon River and 3 redds in the Zigzag River). However, a one year increase above 10% may not indicate that the weirs are having an effect because the proportion of redds observed in each of the stream sections can vary year-to-year, for example the proportion of redds observed in the lower section of the Salmon River ranged from 27% to 50% of the total redds during the 2002-2007 period. If the proportion of redds in these lower sections (where the weirs are located) was consistently 10% above the 2002-2007 average over a three year period, this may indicate that the weirs are affecting spawning distribution, though it may also indicate a change in spawning habitat as described above (Whitman et al. 2014).

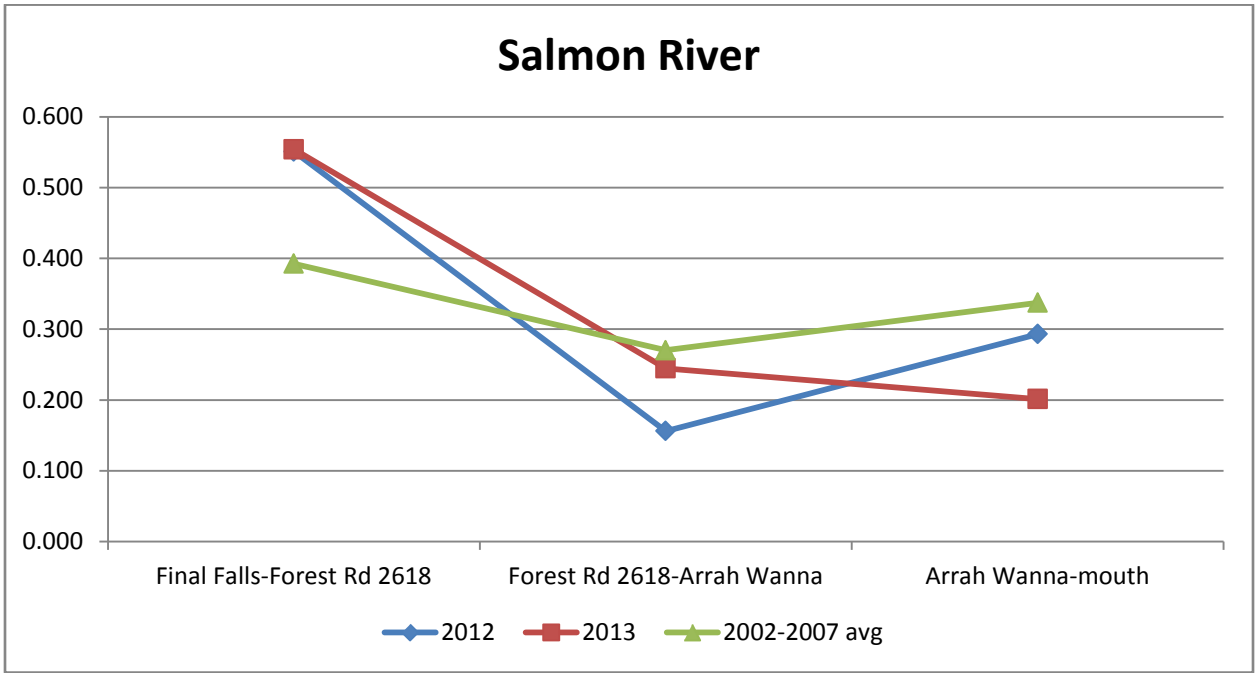

Figure 13. Proportion of the total number of redds observed in three sections of the Salmon River for years 2012, 2013, and the average for return years 2002-2007 (Whitman et al. 2014).

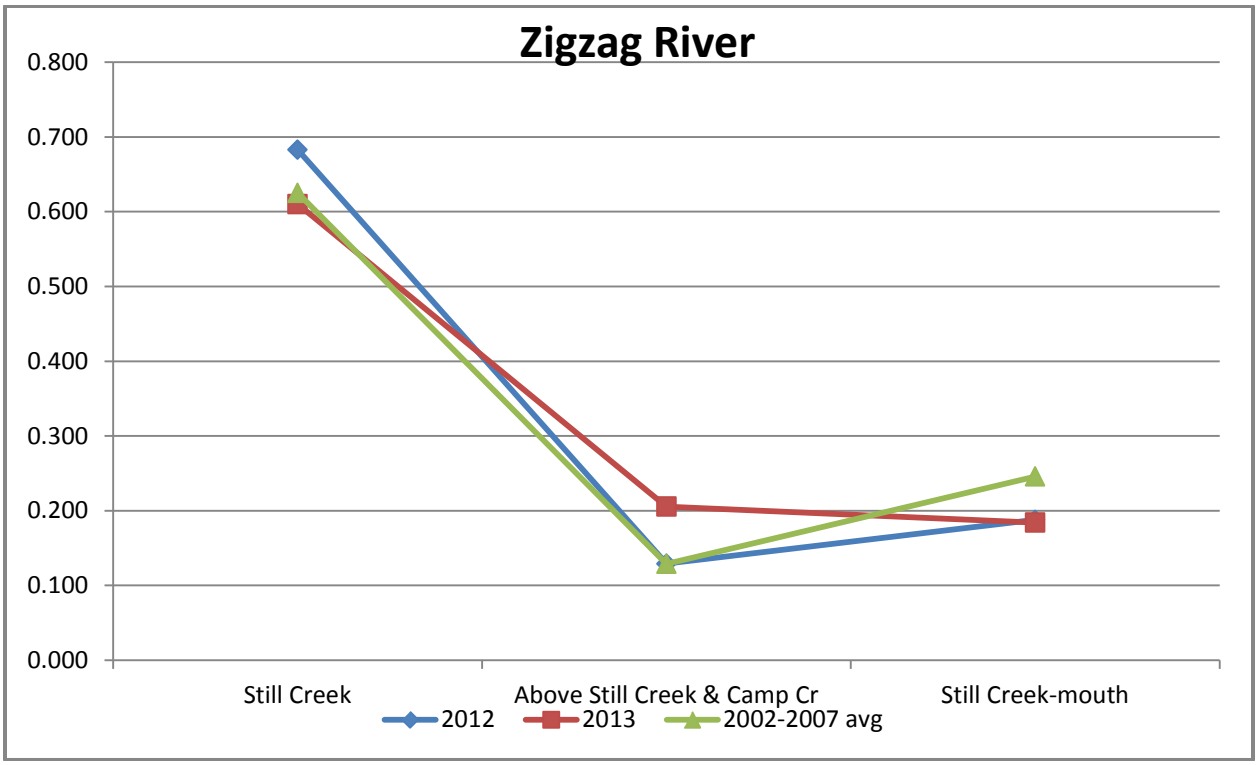

Figure 14. Proportion of the total number of redds observed in three sections of the Zigzag River for years 2012, 2013, and the average for return years 2002-2007 (Whitman et al. 2014).

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 15), but was earlier than the range seen in the past for the upper Salmon River above Arrah Wanna (Figure 15). These are sections or river reaches where data from previous surveys are available (Whitman et al. 2014). 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 still within the range observed in the past (Figure 16). 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. 2014). These 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.

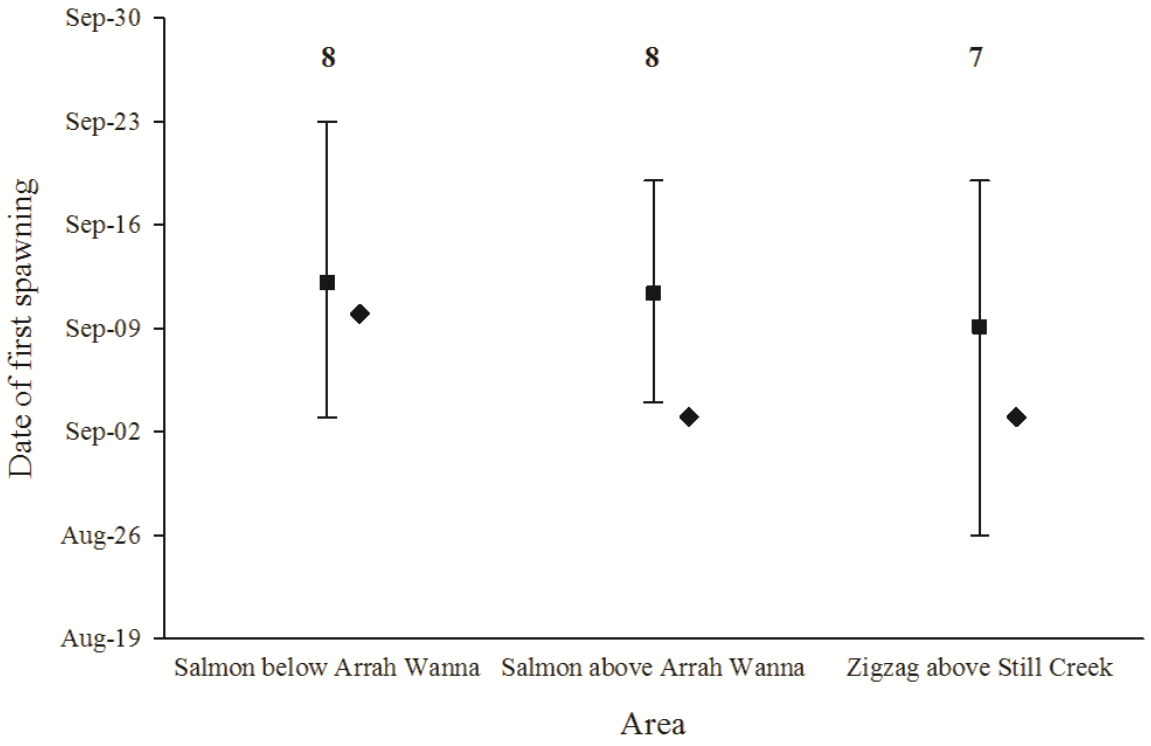

Figure 15. Date of first spawning for spring Chinook salmon in the Salmon and Zigzag river basins for 2002-2009 (mean, ■), and in 2013 (♦). The capped vertical lines are the range and the numbers above the lines are years in the data set. Data for 2010 were not included because surveys started late. 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. 2014).

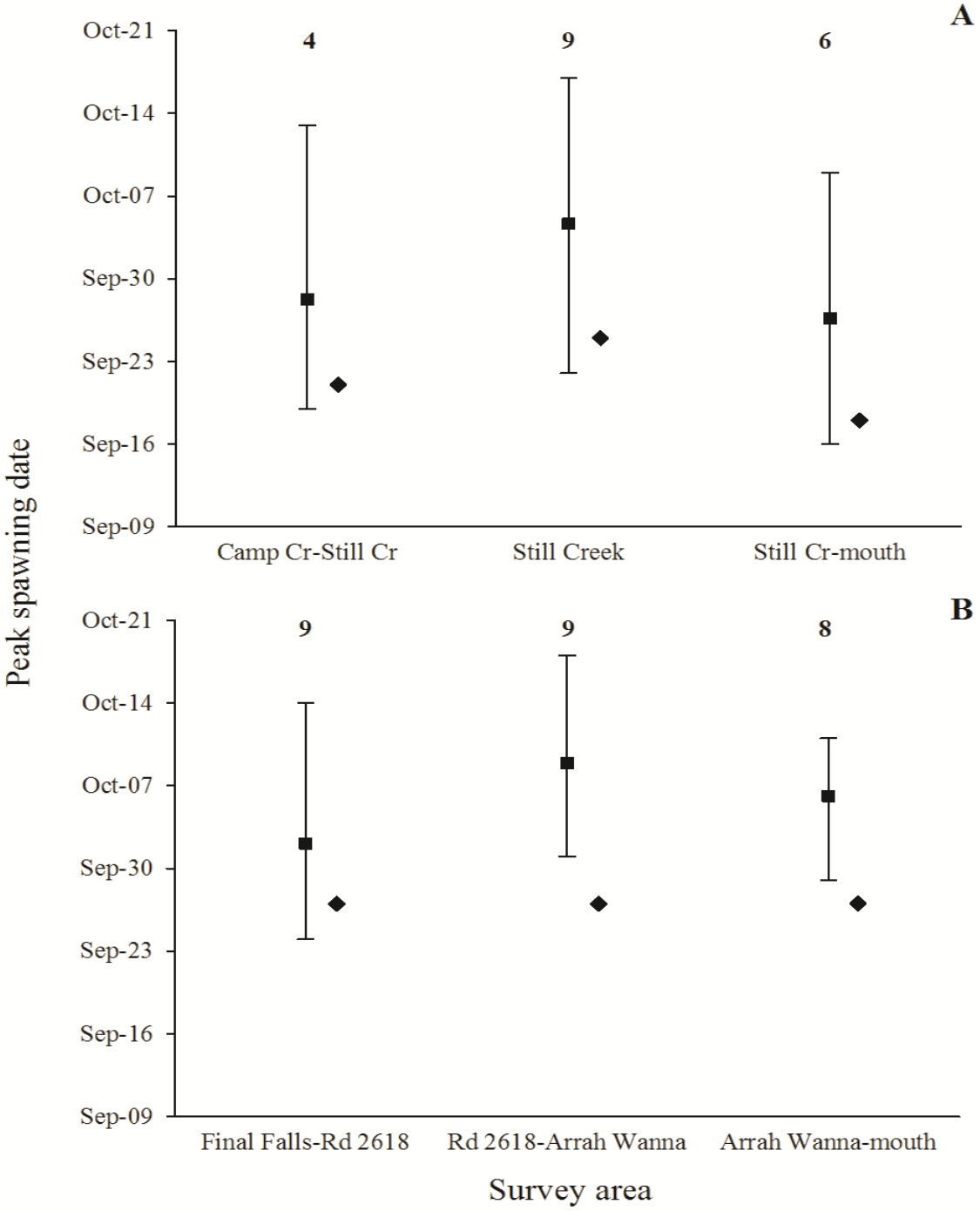

Figure 16. Peak spawning dates of spring Chinook salmon in the Zigzag (A) and Salmon (B) river basins in 2002-2010 (mean, ■) and in 2013(♦). The capped vertical lines are the range and the numbers above the lines are the years in the data set. Years were excluded when only a single survey was conducted (Zigzag River) or when no late surveys were conducted (lower Salmon River)(Whitman et al. 2014).

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 12). 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 (Figures 1 and 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. 2014).

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) is an appropriate surrogate for flows in the Salmon River. Comparing the flow in Blaze Alder Creek with trap counts at the Salmon River weir show the same pattern (Figure 17), 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 for the 2014 season 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 a better picture 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 the a decrease in stream flow, and then an increasing trend the following week as tributary flows increased (Figure 17).

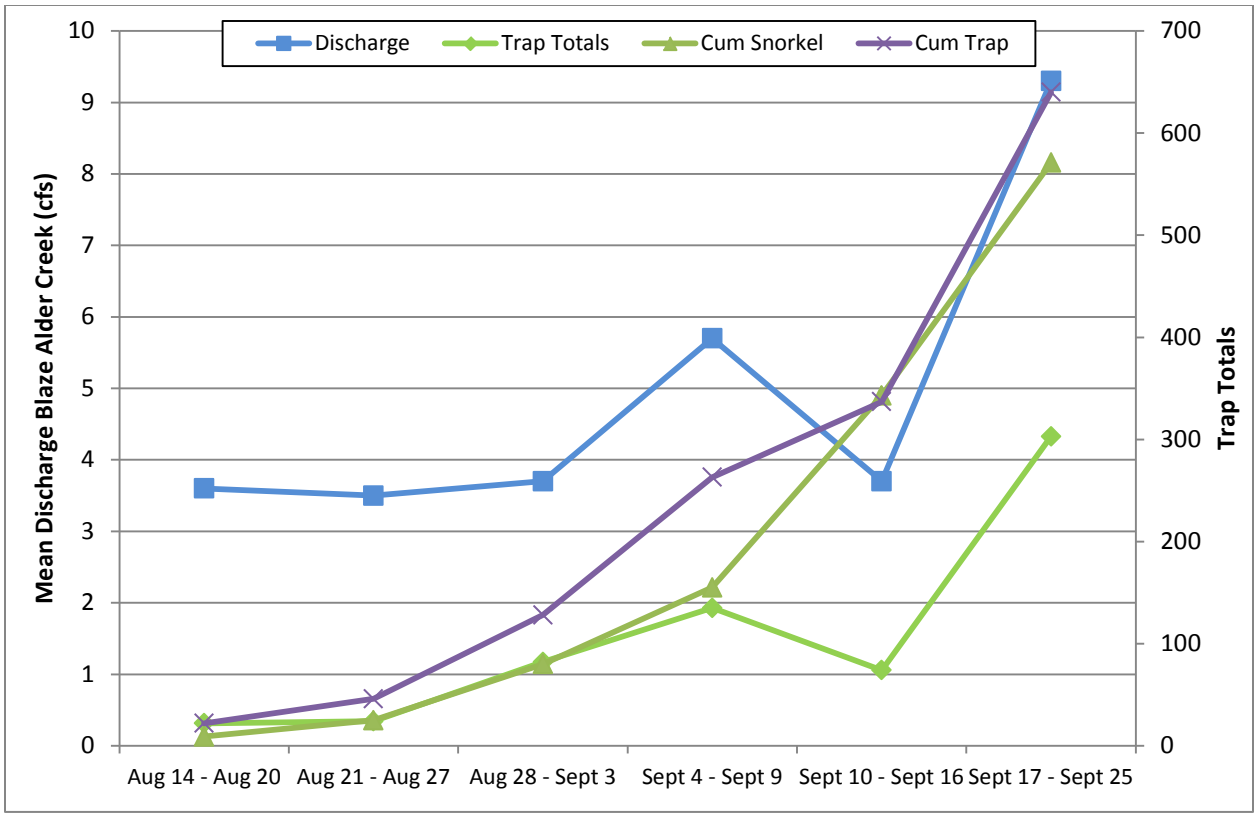

Figure 17. Salmon River trap weekly totals, cumulative snorkel survey counts, and cumulative trap counts relative to Blaze Alder Creek discharge (Blaze Alder Creek is a small un-regulated tributary to the Bull Run River and is used as a surrogate because flow data for the Salmon River is not available) (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. Recall that 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 (see Section 2.3). 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 (pre-spawning mortality) averaged 8.2% in the Salmon River, and 2.9% in the Zigzag River (Whitman et al. 2014). 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 2003-2009 period. They noted that during this period the pre-spawning mortality was variable in the upper Sandy River Basin (range = 0-17%), slightly lower than the variability observed in the upper

McKenzie (range = 0-20%) or the upper Clackamas (range = 0-29%) 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 here is that evidence that hatchery spring Chinook salmon in the Sandy River are subject to substantially higher pre-spawning mortality relative to natural-origin fish means 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) is likely less than previously thought.

Preliminary results from (Whitman et al. 2014), compared pre-spawning mortality in 2013 to that in 2003-2007 (when adults were handled at Marmot Dam) and 2008-2009 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. 2014). 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. 2014). 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 unclipped and fin-clipped spring Chinook salmon in the Salmon and Zigzag watersheds, however the sample sizes were small downstream of the weirs (Whitman et al. 2014). As observed in 2012, 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. 2014).

The estimated pre-spawning mortality was 5% 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. 2014). Estimates of pre-spawning mortality in the Bull Run River Basin prior to 2013 are limited and are not representative due to very small sample sizes.

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 other factors. This is particularly true for Pacific salmon species that have a wide-ranging and complicated life cycle. In this section, we summarize key environmental conditions, including the variability in conditions that are a factor in the analysis of effects for Sandy River hatchery programs.

Stream-flows effect 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% to a high of 1.88% for broodyears 2000 to 2007 (ODFW 2013g). 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. 2014), time of first spawning, (e.g., for the Zigzag River above Still Creek the ranges was from August 25 to September 20th (Whitman et al. 2014) and peak spawning (e.g., in the Salmon River in the upper most section peak spawning ranged from September 24th to October 15th (Whitman et al. 2014). In evaluating the effects of the weir operation 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. This is the primary reason for using a three-year moving average.

Weir Effects on other ESA-Listed Species

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 very 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 50 natural-origin adult coho salmon and 200 adult unmarked summer steelhead could be handled annually. In 2013, the number of adults handed at the weirs totaled 37 unmarked and 1 hatchery coho salmon and 20 unmarked summer steelhead (16 unmarked and one hatchery summer steelhead 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 (Table 2). Based on the mortalities observed for spring Chinook salmon during weir operations, impacts on coho salmon due to handling, even if the maximum number are handled, are expected to be low with no more than 2 natural-origin coho salmon and 5 unmarked summer steelhead mortalities expected 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. 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 winter steelhead and unmarked coho salmon are released above the weir and back into Cedar Creek, to spawn naturally. The Proposed Action estimates that up to 200 adult natural-origin winter steelhead and 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 very 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.

Coho Salmon

Potential genetic effects from hatchery-influenced selection on the natural-origin coho salmon population can occur from hatchery fish spawning naturally. The Proposed Action includes the operation of an isolated coho salmon program using the current stock of hatchery coho salmon released at the Sandy Hatchery. The pHOS goal in the Proposed Action for the coho salmon program is 5%. Best available scientific information shows that of the Sandy Hatchery coho salmon are little enough diverged from the natural population (NMFS 2003b; 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 (NMFS 2003b). For this reason, NMFS considers Sandy River hatchery coho salmon and the Sandy River coho salmon natural population to be integrated. Because of its relatedness to the natural population, NMFS considers the pHOS goal of <5% to be especially protective of the Sandy River natural-origin coho salmon population. HSRG guidelines (HSRG 2009b) for a hatchery using broodstock that is integrated with the receiving natural population is double the level for this program or <10%. It is also important to remember that these standards for pHOS reflect the number of hatchery fish in spawning areas not the number of hatchery fish that "effectively" spawn and pass on their genes (i.e., gene-flow)."Effective" pHOS (see Section 2.4.1.2), is almost certainly lower than the census pHOS (i.e., a more conservative or protective surrogate for hatchery-influenced selection).

A key action implemented to achieve the <5% pHOS goal is a major reduction of Sandy Hatchery coho salmon smolt releases at the Sandy Hatchery from recent levels. Beginning in 2013 and continuing under the Proposed Action, smolt releases have been reduced from over 500,000 annually to 300,000 (Figure 9). All of the coho salmon production will 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. In 2012, the coho salmon pHOS (ODFW 2013c), from releases of approximately 500,000 smolts. ODFW will monitor and report on pHOS annually, but based on the 2012 data, NMFS concludes that a pHOS of < 5% will be achievable with a 40% reduction in smolt release. In 2013, pHOS was 11.8%, from a release of 463,000 smolts. The actual effective pHOS was no doubt less because the majority of the marked hatchery fish were observed in the lower Sandy River tributaries, compared to 96% of the estimated natural-origin spawner abundance that was in the upper basin areas where pHOS was estimated to be 5%. Considering this information, the "effective" pHOS would have been around 7% (Eric Brown, ODFW, personal communication). Based on available information it is NMFS' opinion that the genetic effects pose a low risk to the natural-origin Sandy River coho salmon population.

Winter Steelhead

In terms of genetic risk issues, the winter steelhead hatchery program is very 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 broodyear, was derived from the local natural-origin population, and it incorporated natural-origin adults into the broodstock through 2011. 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 2003b; 2004b; Jones 2011). Because of this close relationship to the natural-origin winter steelhead population, NMFS considers the Sandy River hatchery winter steelhead and the Sandy River natural-origin winter steelhead population to be integrated.

The Proposed Action would manage the winter steelhead hatchery program as an integrated program, with a pNOB of 20% (0.2), and a pHOS goal of <10% (0.1), for a PNI of 0.67 based on a three-year moving average. These criteria meet the HSRG's guidelines for an integrated program impacting a population of high conservation value (one with very low risk of extinction). Based on recent experience and the operations proposed NMFS concludes that hatchery-influenced selection from the Sandy Hatchery winter steelhead program pose a low risk to the natural-origin Sandy River winter steelhead population.

As in the case for spring Chinook salmon, the natural-origin winter steelhead used for broodstock will be exclusively male. We analyzed the use of only male natural-origin fish in the broodstock as a means to maintain integration of the hatchery program and natural-origin winter steelhead population. This reliance on natural-origin males could be a risk if the traits undergoing selection were sex-linked. As mentioned above in the discussion for spring Chinook salmon, a considerable amount of research is currently underway with *O. mykiss* on the genetic basis of quantitative traits. Although the level of sex-linkage discovered this far indicates that use of only one sex could result in a selection response different from one carried out on both sexes, it is not at all obvious at this point that this practice in the Sandy winter steelhead program poses a significant risk, especially when the single-sex part of the program involves only 20% of the broodstock. NMFS' opinion on this may change however, as more research results become available.

Previously, the primary method for reducing hatchery winter steelhead pHOS was to remove hatchery adults at Marmot Dam (ODFW 2013g). Under the Proposed Action, best management practices for steelhead acclimation and release will 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 will continue as described in the Propose Action (see Section 1.3.3), but this is not expected to pose a risk to meeting criteria for pHOS. Recycling of hatchery winter steelhead will be

discontinued if monitoring shows that the three-year moving average exceed s the <10% 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 very small sample sizes and therefore of limited value. For example, the 2010 pHOS estimate of 29% was based on 7 live adults being observed with 2 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% pHOS were based on 19 and 3 live winter steelhead observed, all with adipose fins. NMFS does not believe that pHOS was zero. 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 2013g). The pHOS estimate of 6.4% was based on a sample size of 47 observed known-mark winter steelhead.

ODFW will continue monitor escapement of natural-origin winter steelhead that are passed above the hatchery to spawn naturally in upper Cedar Creek. 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% 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 five years ending in 2019, 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 will be monitored using a rotary screw trap to collect juvenile outmigrants (see Section 1.3.5). Under the Proposed Action, no-hatchery winter steelhead will be passed above the hatchery for a period of five years (2019), at which time the success of the recolonization will be evaluated. If returns and productivity estimates based on juvenile outmigration monitoring show that the these releases are not fully seeding the habitat, ODFW will devise a plan, to be submitted to NMFS for approval before implementation, to supplement the natural-origin population with returning hatchery winter steelhead. The integration of the winter steelhead program with natural-origin winter steelhead population allows this program to act as a safety-net for that proportion of the Sandy River population that spawns in Cedar Creek.

Summer Steelhead

The Proposed Action includes an isolated summer steelhead program that continues the current 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 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 Proposed Action includes a pHOS goal of <5%, based on a

three-year moving average. Based on best available information, NMFS concludes that this pHOS goal can and will be met, and poses a low risk to the natural-origin Sandy River winter steelhead population. Bolstering this conclusion is the knowledge that there is very little overlap between the natural spawn timing of 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 in the Proposed Action 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% adipose fin-clipping that will 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. NMFS expects that these practices and management actions, combined with the natural spawn timing between hatchery summer steelhead and natural-origin winter steelhead, will ensure that the pHOS goal will continue to be met. The recycling of hatchery summer steelhead to provide additional harvest opportunities will continue as described in the Proposed Action (see Section 1.3.4), but only if annual monitoring shows that three-year moving average for pHOS is <5%.

Compared to salmon, steelhead are difficult to enumerate on the spawning grounds because of their protracted spawning period and because 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 (see discussion in Section 2.3), 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 very few steelhead have been observed during the coho salmon surveys even though around 56% of the habitat surveyed during coho spawning surveys overlaps with winter steelhead habitat. These surveys provide on-the-ground observations information of whether or not summer steelhead are spawning prior to the month of February and constitute the best available information for monitoring compliance with the <5% summer steelhead pHOS goal. Based on the most recent survey information, NMFS concludes that the summer steelhead pHOS goal can and will be met, and it is therefore NMFS' opinion that genetic effects from this level of pHOS pose a low risk to natural-origin Sandy River winter steelhead population.

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

Negligible effect: Hatchery smolts and the juvenile progeny of naturally spawning hatchery Spring Chinook salmon, coho salmon, and winter and summer steelhead are expected to have a negligible effect on natural-origin juveniles.

The most important considerations here 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.

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. 2014). This spatial segregation is expected to 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 hatchery coho salmon and steelhead compared to natural-origin coho salmon and steelhead populations, and the lower reproductive success for naturally spawning hatchery fish are 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).

Another action that is expected to mitigate the potential for competition between hatchery and natural-origin fish 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. Hatchery spring Chinook salmon smolts will be acclimated and released from the Bull Run acclimation pond which is also downstream of the primary natural production areas for salmon and steelhead in the Sandy River creating greater spatial separation between hatchery adults, the progeny of naturally spawning hatchery fish, and natural-origin salmon and steelhead in the Sandy River. Another mitigating factor is the dramatic declines in hatchery production/smolt releases – coho smolt releases have declined by more than 40 percent, and spring Chinook salmon releases have declined by 70% (Figure 9).

In addition, unmarked summer steelhead trapped at the Bull Run weir will be released below the weir after sampling, and those collected at the upper basin weirs will be transported and released at the Lewis and Clark Park in the lower Sandy River. This will allow those possibly ESA-listed summer steelhead to escape back to the mainstem Columbia River to continue their upstream journey while at the same time preventing mis-marked hatchery summer steelhead from being trapped above the weirs in the primary winter steelhead habitat. By limiting the potential for non-

endemic summer steelhead to spawn naturally, competitive interactions with natural-origin salmonid populations will be avoided. Ecological interactions between summer steelhead and winter steelhead were identified as contributing to declines in the productivity of the winter steelhead population (Kostow and Zhou 2006).

Natural-origin Chinook and coho salmon and steelhead do not smolt and head for the ocean all at once – they instead have a more protracted emigration, leaving rearing areas far upstream in the Sandy Basin over the course of several months. This is in stark contrast to hatchery fish that are relatively uniform in size and behavior and leave the hatchery en masse, and likely will spend only hours or days in the lower Sandy River before they reach the Columbia River and join more than a hundred million natural-origin and hatchery smolts bound for the Pacific Ocean. This behavior or habit is witnessed and 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 in masse and would overwhelm the trap if it continued to operate during the hours immediately following hatchery fish release from the pond. 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 smolts totaling 97,756, and following the procedure described above, only 72 hatchery spring Chinook salmon smolts were trapped, or less than 0.07% of the total release was captured two days or more after release. Similarly in 2013, after two releases totaling 129,923 smolts, only 237 were trapped, or 0.15% of the total release. Trap efficiency is not 100% but these numbers clearly illustrate how quickly the hatchery spring Chinook salmon smolts emigrate after release.

Based on the sum total of information available to NMFS, competition from hatchery fish poses a low risk to ESA-listed natural-origin populations in the Sandy River. NMFS expects that the majority of the hatchery salmon and steelhead smolts will leave the Sandy River within 21 days of their release. To confirm this, ODFW will 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 move quickly and do not stay long in the Sandy River to interact with and potentially compete with natural-origin fish (Alsbury 2013b). No hatchery spring Chinook salmon and coho salmon were present during sampling in these lower river areas and only a very small number of hatchery steelhead were encountered (Alsbury 2013b).

Displacement

At other locations, 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. For the Sandy River, this possibility 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 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. Because there is little temporal or spatial overlap between hatchery smolts and natural-origin fish, there is no known threat from predation or competition. As with the discussion of competition, available data shows that hatchery smolts leave the system promptly and that only a small fraction remains in the system 21 days after release, and ODFW will monitor the river for the presence of hatchery smolts in this time frame. 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. For the purposes of expanding our understanding of hatchery fish outmigration and the potential for competition between hatchery and natural-origin fish, NMFS has required that ODFW monitor and report annually on the presence and absence of juvenile hatchery fish in the Sandy River downstream of the Sandy Hatchery. 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 2 steelhead smolts, no other hatchery origin juveniles were observed out of the 525 juveniles sampled (Alsbury 2013b).

The risk of adverse ecological interactions will 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.

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

Negligible effect: Best available information does not indicate that the release of hatchery fish from the Sandy River programs would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean and thus, NMFS concluded that this factor is not a threat.

NMFS has been investigating this factor for some time. The Proposed Recovery Plan for Snake River Salmon (NMFS 1995) described the issue in this manner. 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 in fact, 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 back in the late 1990s.

More recently, NMFS reviewed the literature for new and emerging scientific information over the role and the consequences of density-dependent interactions. At full production, hatchery releases from the four Sandy River programs will constitute less than one percent of the total hatchery production and less than .05 percent of all juvenile salmonids in the Columbia basin. The SCA for the FCRPS opinion (NMFS 2008i) 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 small 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 very unlikely to substantially affect salmon survival or recovery in these life stages. NMFS will monitor emerging science and information and will reinitiate Section 7 consultation in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4.2.5. Factor 5. Research, monitoring, and evaluation that exists because of the hatchery program

Minor Negative effect: The Proposed Action includes ME&R activities that will continue to monitor the Performance Indicators identified in Section 1.10 of the HGMPs, ensure compliance with this opinion, 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. Very 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 will 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 are also monitored at the weirs, including the weir on Cedar Creek, and the effect on natural-origin adults is addressed above (Section 2.4.2.2). In 2013, the first year of operation, the rotary screw trap handled 376 coho salmon and 14 steelhead smolts and 44 coho salmon fry (<70 mm), and 78 steelhead fry (Strobel 2014). The only mortalities were two coho salmon smolts and 2 coho salmon fry.

Masking caused by hatchery fish is not a threat to ESA-listed salmon and steelhead in the Sandy River. Hatchery fish from these programs will 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 will 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 will 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 well 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.

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

Negligible effect: NMFS also evaluated the construction, operation, and the maintenance of hatchery facilities associated with the four hatchery programs in the Sandy basin and concluded that this factor has a negligible effect on ESA-listed species. What NMFS evaluates here is how the facilities themselves affect the fish and designated critical habitat. Water intake structures and water withdrawal present another set of potential effects on listed salmonids. Each facility with intakes, pumps and screens has the potential to impact fish, as does the release of effluent. Below we consider these potential impacts for each facility.

The new diversion facility at Sandy Hatchery, completed in summer 2013, has improved juvenile and adult passage in the bypass reach at the Sandy Hatchery. The diversion intake is screened and meets NMFS criteria for protecting anadromous salmonids, and minimum flows are required in the bypass reach to provide for juvenile migration and rearing.

The Bull Run acclimation pond pumps water from the Bull Run River up to the pond, where it passes once through the pond and returns to the river immediately below the pump intake such that there is no discernable impact on river volume or rearing habitat.

The Sandy Hatchery is operated under NPDES permit # 10598. Effluent from the hatchery is monitored weekly to ensure compliance with permit requirements. The Bull Run acclimation pond does not need a NPDES permit because rearing levels in the acclimation pond are below permit minimums. All of the other facilities that rear salmon and steelhead for the Sandy River programs also have NPDES permits and the effluent from the facilities is monitored to ensure compliance (see Section 1.3).

Oxbow Hatchery, Bonneville Hatchery, and Oak Springs Hatchery all use spring water when rearing salmon and steelhead for the Sandy River Hatchery programs, and thus have no impact on surface water or ESA-listed species.

Adult spring Chinook salmon from the Sandy River program are held at the Clackamas Hatchery prior to spawning. During this period, the peak surface water use at the Clackamas Hatchery is less than 2% of the lowest flow during that period and any effects are limited to a ¼ mile section of the Clackamas River. At present, the intake screens do not meet NMFS criteria, but there are plans to upgrade them to meet these standards for protecting fish. The lowest flows in the mainstem Clackamas River occur in September, and during this time up to 2% of the flows would be withdrawn for hatchery use. During the month of September, approximately 6,000 juvenile coho salmon, Chinook salmon, and steelhead were counted passing into the Clackamas

River below River Mill Dam and upstream of the hatchery intake. At a maximum 2% of the flow going into the hatchery, and assuming that the juveniles are equally distributed in the river, 120 juveniles could be encountered by the intake screens. However, taking into account the habitat preferences for juvenile salmonids, the number of juvenile salmonids that would be impacted is expected to be substantially less. The removal of up to 2% of the water volume would not be expected to attract juvenile fish to the intake structure further reducing the possibility of ESA-listed fish being effected by the water withdrawal. If juvenile fish do approach the intake screens, the screens are effective in preventing juveniles from enter the hatchery, but the fish may become temporarily impinged on the screen because it does not meet screen opening size and surface area criteria.

The Cascade Hatchery will be used to rear Sandy River spring Chinook salmon from July through October, before they are transferred to the Sandy Hatchery in November. During this period, on average approximately 16% of the water used at the hatchery is for the Sandy River spring Chinook salmon program. Cascade Hatchery uses water from Eagle Creek. The hatchery water intake structure is located at RM 0.8 and is a barrier to fish passage, except at high flows when steelhead have been observed passing over the structure. A natural falls on Eagle Creek, located 1.2 miles upstream of the intake structure, creates a natural barrier to all fish passage. The U.S. Forest Service conducted an aquatic habitat inventory survey and reported that the habitat above the barrier is high gradient (not preferred by salmon or steelhead), has limited instream large woody debris due to high velocities and frequent flooding, and supports very limited over wintering habitat for salmonids (ODFW 2002). Because of the quality of the limited habitat and due to disease concerns, ODFW, with approval of the Oregon Fish and Wildlife Commission, decided not to provide passage above the barrier. Adult salmon and steelhead in the hatchery water supply can introduce diseases into the hatchery affecting hatchery programs that are needed to meet Indian Treaty-Trust obligations under the *U.S. v. Oregon* Agreement (ODFW 2002). ODFW has proposed to use habitat mitigation to compensate for any lost production.

2.4.2.7. Factor 7. Fisheries that exist because of the hatchery program

Not Applicable. Fisheries in the Sandy River Basin and their management are not included as part of the Proposed Action. Fisheries targeting hatchery fish produced under the Proposed Action were described and evaluated in separate opinions (NMFS 2003c; 2008d; 2008h). These effects are therefore incorporated into the environmental baseline.

2.4.3. Effects of the Action on Critical Habitat

Negligible effect: This consultation analyzed the Proposed Action for its effects on designated critical habitat and has determined that operation of the hatchery programs will have a negligible effect on PCEs in the Action Area, but may have an overall beneficial effect in the Sandy River Basin. The beneficial effects on critical habitat in the Sandy River are from the introduction of marine-derived nutrients from naturally spawning hatchery fish and from surplus hatchery salmon and steelhead carcasses that are annually outplanted into Sandy River tributaries. As described in Section 2.4.1.2, the hatchery 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. These marine-derived nutrients can increase the growth and survival of the ESA-listed species by affecting PCEs

associated with juvenile rearing such as increasing forage species (i.e., aquatic and terrestrial insects), aquatic vegetation, and riparian vegetation to name a few. The continued input of hatchery salmon and steelhead carcasses is expected to benefit the recovery of natural-origin populations in the Sandy River Basin.

Other possible effects on critical habitat from the Proposed Action would occur in freshwater migration corridors. The hatchery facility itself would not require additional construction or disturbance of riparian or streambed habitat, and the any effects of water withdrawal and effluent are expected to be small and transitory. Hatchery intakes are screened to prevent fish injury from impingement or permanent removal from streams. The operation of the adult weir and intake structure at the Sandy Hatchery on Cedar Creek would not be expected to impact natural-origin spring Chinook salmon because Cedar Creek does not contain spring Chinook salmon spawning or rearing habitat. Access to habitat in Cedar Creek above the Sandy Hatchery has been provided to natural-origin coho salmon and winter steelhead.

The effects on critical habitat of pumping water for the Bull Run acclimation pond are expected to be negligible because the pump would be screened to meet NMFS criteria, the water would be returned to the same pool where it was removed, and the pond would be operated during periods of high flows in the Bull Run River.

Impacts on migration and rearing habitation for juvenile coho salmon and winter steelhead would occur when the flow in Cedar Creek is reduced to provide water to rear coho salmon at the Sandy Hatchery. These impacts would be expected to be the greatest during September, when flows in Cedar Creek tend to be at their lowest. The numbers affected, if any, would be expected to be small, because water temperatures in that area become elevated during the summer months, reducing the quality of the rearing habitat. In addition, ODFW will maintain minimum flows to ensure juvenile passage to meet Oregon's Native Fish Conservation Policy (ODFW 2003d). Impacts would be expected to be temporary and only last until fall rains increase flows in Cedar Creek.

Habitat impacts from the installation and operation of the weirs are expected to be limited to the weir location, and to be of a short duration. Habitat will be temporarily impacted by the placement of the weirs. Each weir is designed to be installed and removed annually, eliminating the requirement for permanent structures in the river. When the weirs are operational, they will impact the PCEs for migration as follows:

- The installation of the weirs in the Zigzag River, the Salmon River, and the Bull Run River in early June could potentially lead to the handling of the majority of natural-origin spring Chinook salmon returning to the Sandy River Basin. Monitoring associated with spawning ground surveys would be used to determine if the presence of the weirs caused natural-origin spring Chinook salmon to spawn downstream of the weirs.
- The weirs, if installed by the first of June, may encounter winter steelhead kelts (fish that have already spawned) migrating out of the basin. No kelts have been encountered to date and future encounters are 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 (Schroeder et al. 2013). Adult winter steelhead would not be expected

to be encountered during weir operations because they return after the weirs are removed and before the weirs are installed.

- Impacts on coho salmon would occur on that proportion of the adult returns that enter the upper Sandy River prior to the removal of the weirs. ODFW proposes to use the observed presence of coho salmon as an indicator as to when to remove the weirs for the season. Impacts are expected to be low because only a few coho salmon would be handled.

Indications that the handling of natural-origin adults at the weirs could contribute to pre-spawning mortality would be monitored by the evaluation of carcasses that are recovered during spawning ground surveys. Spawning surveys in 2012 did not identify any increase in pre-spawning mortality associated with the handling of adults at the weirs (Schroeder et al. 2013). Spawning surveys in 2013 did not identify any affects associated with weirs, such as passage delay. In the future, if effects to natural-origin fish are discovered, they will b mitigated through adjustments in weir design and placement, the use of trained personnel, and operations that minimize the time salmon and steelhead are held or delayed at the weirs (Whitman et al. 2014).

Operation of the hatcheries and acclimation pond that support the Sandy Hatchery programs are not expected to degrade water quality. All hatchery facilities have current NPDES permits, and effluent would be monitored to ensure compliance with permit requirements.

Oxbow Hatchery, Bonneville Hatchery, and Oak Springs Hatchery all use spring water when rearing salmon and steelhead for the Sandy River hatchery programs, and thus will not impact surface water or critical habitat for ESA-listed species.

Adult spring Chinook salmon for the Sandy River hatchery program are held at the Clackamas Hatchery prior to spawning. During this period, the peak surface water use at the Clackamas Hatchery is less than 2% of the lowest flow during that period and the effects are limited to a ¼ mile section of the Clackamas River. At present the intake screens do not meet NMFS criteria, but there are plans to upgrade the intake screens. The lowest period flow in the mainstem Clackamas River occurs in September when up to a maximum of 2% of the flows would be withdrawn for hatchery use. The removal of less than 2% of the river volume would not be expected to be detectable to adult or juvenile migrants in the ¼ mile section affected.

The Cascade Hatchery is used to rear Sandy River spring Chinook salmon from July through October before they are transferred to the Sandy Hatchery in November. The Cascade Hatchery operates a hatchery water intake structure located are RM 0.8 on Eagle Creek that is a barrier to fish passage, except at high flows when steelhead have been observed passing over the structure. During the summer months the hatchery reduces flow in the section of Eagle Creek from the intake at RM 0.8 to the hatchery outfall at RM 0.2, only minimal flows are provided. This would impact the quality of the migration and rearing habitat in that section. However, during the summer months the pool behind Bonneville Dam is operated at levels such that a large proportion of the bypass section becomes part or the reservoir and consistently reaches temperatures above 70°F, rendering this habitat unsuitable for salmonid rearing. As described in ODFW (2002), habitat quality in this section and the area from the intake to the natural falls on Eagle Creek located 1.2 miles upstream of the barrier is very poor due to the high gradient, and limited instream large woody debris due to high velocities and frequent flooding, limiting the

quality of habitat for salmonids. NMFS did identify the habitat below the falls as spawning and rearing habitat for LCR steelhead based solely on access to this area. Any juveniles that may be produced in the habitat below the intake structure, primarily fall Chinook salmon, would emigrate from this section prior to the summer period to avoid high water temperatures. The reduction in flow is not expected to reduce the quantity or quality of freshwater rearing habitat to the levels that would have any discernable effects on ESA-listed salmon or steelhead juveniles or adults that may be present in the area adjacent to the Cascade Hatchery during the rearing of spring Chinook salmon for the Sandy Hatchery program.

Operation and maintenance activities would include pump maintenance, debris removal from intake and outfall structures, building maintenance, and ground maintenance. These activities would not be expected to degrade water quality or adversely modify designated critical habitat, because they would occur infrequently, and only result in minor temporary effects.

Non-routine maintenance (e.g., construction of facilities or reconstruction of in-river hatchery structures) is not considered in this opinion and would require separate consultation.

2.5. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the Action Area of the Federal action subject to consultation (50 CFR 402.02). For the purpose of this analysis, the Action Area is that part of the Columbia River Basin described in the Section 1.4. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the environmental baseline (whether they are federal, state, tribal, or private). To the extent those same activities are reasonably certain to occur in the future (and are tribal, state, or private), their future effects are included in the cumulative effects analysis. This is the case even if the ongoing, tribal, state, or private activities may become the subject of Section 10(a)(1)(B) incidental take permits in the future. The effects of such activities are treated as cumulative effects unless and until an opinion has been issued.

Some of the state and private activities that are included in the baseline for this consultation are expected to continue in the future, i.e., the City of Portland's Bull Run municipal water supply facility and its related HCP, agricultural activities, timber harvest, residential and commercial development, as well as a variety of restoration projects. Effects of these activities at current levels are described in the Environmental Baseline (Section 2.3) and are not expected to change appreciably.

The LCR Salmon and Steelhead Recovery Plan and the LCR Conservation & Recovery Plan for Oregon populations of Salmon and Steelhead (ODFW 2010) describes, in detail, the on-going and proposed state and local government actions that are targeted to reduce known threats to listed LCR Chinook and coho salmon and to steelhead in the Sandy River Basin. It is acknowledged, however, that such future state and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives, and land use and other types of permits and that government actions are subject to political, legislative and fiscal uncertainties.

2.6. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the benefits and risks posed to ESA-listed species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS add the effects of the Proposed Action (Section 2.4.2) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to formulate the agency's opinion as to whether the Proposed Action is likely to: (1) reduce appreciably the likelihood of both survival and recovery of the ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat. This assessment is made in full consideration of the status of the species and critical habitat and the status and role of the affected populations in recovery (Sections 2.2.1, 2.2.2, and 2.2.3).

In assessing the overall risk of the Proposed Action on each species, NMFS considers the benefits and risks of each factor discussed in Section 2.4.2, above, in combination, considering their potential additive effects with each other and with other actions in the area (environmental baseline and cumulative effects). This combination serves to translate the positive and negative effects posed by the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciably reduce the likelihood of survival and recovery of the ESA-listed species and their designated critical habitat. To do this, NMFS considers how all of the effects impact individuals within the different populations and how these impacts on individuals affect the VSP parameters for those populations. If there are changes to the VSP parameters from the Proposed Action, NMFS then determines whether the changes in VSP parameters affects the overall status of the population, and then determines if the resulting change in the overall status of the population affects the likelihood of survival and recovery of the entire ESA-listed ESU/DPS (i.e., the species). Similarly, NMFS considers how all these impacts affect critical habitat in the Action Area and whether these impacts adversely modify the habitat such that the status of the ESA-listed population is affected.

2.6.1. LCR Chinook Salmon

NMFS believes the proposed action will adequately contain effects on natural-origin LCR Chinook salmon, and that the status of the ESU will not be undermined in the process. As discussed above, we find that the hatchery Chinook salmon in the Sandy River are no more than moderately diverged from the natural-origin population, that straying of hatchery fish has not damaged the prospects for recovery, and that the program going forward includes adequate safeguards to assure that straying will be limited in a way that continues to adequately contain the risk of hatchery effects.

Take effects analysis shows minimal risk associated with the Proposed Action. NMFS analyzes seven factors to determine the effects of a hatchery program on ESA-listed species and on designated critical habitat (Section 2.4.2). The amount and effect of the take on the ESA-listed Chinook salmon, as detailed in Section 2.4, are summarized below; for the majority of the activities where take occurs, NMFS found that the effects are expected to be negligible (Table 8), except for take associated with broodstock collection including the operation of the weirs, hatchery adults spawning naturally, and ME&R activities (Table 2).

NMFS has determined that the Sandy River hatchery spring Chinook salmon are no more than minimally diverged from the natural-origin population. This determination is based on the best scientific information available, that shows that the hatchery program was recently initiated used only natural-origin Sandy River spring Chinook salmon and that the natural-origin spring Chinook salmon have been incorporated into the broodstock (until the last three years) at levels such that there is no appreciable genetic difference between the hatchery spring Chinook salmon and the natural-origin population (NMFS 2003a; 2004b).

NMFS has determined that past hatchery straying has not placed the natural-origin population at great risk such that further genetic introgression threatens to seriously impact the natural-origin population. Prior to the removal of Marmot Dam, hatchery fish were effectively removed at the dam and prevented from spawning in the important upper-basin spawning areas. After the removal of Marmot Dam in 2007, pHOS increased substantially from 45.2% in 2008, to a peak of 77.1% in 2010.

The high proportions of hatchery spring Chinook salmon spawning naturally after the removal of Marmot Dam (Table 6) far exceeded the management and recovery plan pHOS goal of <10% (ODFW 2010), but genetic effects were actually less than what would be expected considering only the high census pHOS observed. This is because the PNI remained above the threshold for high risk throughout this time, largely due to the use of natural-origin spring Chinook salmon in the broodstock. The HSRG (2009c) recommends for natural populations that are managed to achieve high viability (i.e., very low risk of extinction or high persistence), that the PNI should exceed 0.67 (Section 2.4.1.2) and since spring Chinook returning in 2008 and 2009 included hatchery adults derived from only natural-origin adults, the PNI for these years was approximately 0.67. For 2011, pHOS increased and pNOB decreased, meaning that PNI declined to a low of 0.54, but this was still above the 0.50 which indicates that natural selective forces exceed or are dominating hatchery selective forces.

More recently, because only hatchery adults were used for broodstock in 2011, 2012, and 2013 (where pNOB was zero), PNI has become a temporarily ineffective measure of risk and pHOS becomes more critical, but pHOS has steadily declined as measures such as weirs, reduced production, acclimation/release strategies have taken effect. In 2013, pHOS was an estimated 9.3%.

Pursuant to the Proposed Action, natural-origin adults will be used for broodstock beginning with the 2014 broodyear and PNI will again become the best measure of potential risk. Since pHOS is required to be less than 10% (using a three-year moving average), then PNI would be expected to be above 0.66 in return year 2019, and remain above that level, consistent with the HSRG guidelines (HSRG 2009c). The long-term effect of this on the Sandy River natural-origin spring Chinook salmon population would be an increase in population diversity and productivity as the influence of past out-of-basin hatchery releases and high pHOS levels diminish. The increase in productivity would result in an increase in abundance as well.

As discussed in Section 2.4.1.2, NMFS reviewed the modeling analysis in Oregon's LCR Recovery Plan (ODFW 2010) and determined that maintaining a <10% pHOS goal for the Sandy River spring Chinook salmon population, along with other recovery actions, would be expected

to increase VSP parameters to the point where the Sandy River spring Chinook salmon population would be viable and at very low risk of extinction (ODFW 2010). The <10% pHOS goal is also consistent with TRT guidelines 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, in addition to meeting abundance and productivity targets for this designation, the average pHOS must to be <10%.

This concept of a pHOS of <10% not appreciably affecting viability is further supported by Figure 11. This figure shows the expected proportion of mating types (natural-origin x natural-origin, natural-origin x hatchery, and hatchery x hatchery) in a population as a function of the proportion of hatchery-origin fish on the spawning grounds (i.e., pHOS), assuming that natural-origin and hatchery adults mate randomly, and are equally successful reproductively. Using a pHOS of 10%, Figure 11 shows that 81% of the matings would be natural-origin x natural-origin, 18% would be natural-origin x hatchery, and 1% would be hatchery x hatchery crosses. This high a proportion of natural-origin x natural-origin matings should ensure a high degree of adaptation to the natural environment in the Sandy River as opposed to adaptation to hatchery rearing. As described above in Section 2.4.2.2, the pre-spawning mortality for hatchery spring Chinook salmon was twice that observed for natural-origin spring Chinook salmon, this translates into lower reproductive success for hatchery fish spawning naturally, and thus the actual level of natural-origin x natural-origin crosses would be higher than the modeled 81%. What this means, is that for almost the entire population at least one parent would be of natural-origin and more than 8 of 10 matings would be between natural-origin adults such that the contribution of hatchery produced spring Chinook salmon to the next generation would be minimal and would not be expected to adversely impact the viability of the natural-origin population.

As described in the HGMP (ODFW 2013b), ODFW has implemented a number of actions to reduce the spring Chinook salmon pHOS, including: acclimating and releasing hatchery spring Chinook salmon at the Bull Run acclimation pond, reducing the number of juveniles released, and using seasonal weirs (the operation of the weirs was discussed in Section 2.4.2.2). Returns from juvenile spring Chinook salmon released at the Bull Run acclimation pond began with 45 fin-clipped spring Chinook salmon being trapped and 18 unclipped adults being passed upstream at the Bull Run weir in 2013. Also in 2013, spring Chinook salmon adults returning from releases at the Sandy Hatchery were able to enter the hatchery via Cedar Creek where 444 adults were collected and removed at the hatchery (McIntosh 2013b). All of these contributed to achieving the estimated pHOS of 9.3% in 2013.

Impacts from the reduction in release numbers and from acclimating juveniles at the Bull Run acclimation pond will not be fully realized until at least 2016, when adults returning to the Sandy River will all be from releases at the Bull Run acclimation pond and from the reduced production levels. It is anticipated that, when returns from the Bull Run acclimation pond can be collected at the Bull Run weir, the operation of the weirs in the upper basin may not be necessary to achieve the <10% pHOS goal. This would further reduce impacts on the Sandy River spring Chinook salmon population. Note that through July 17, 2014, 89 hatchery spring Chinook salmon have already been collected at the Bull Run weir, almost double what was collected over the entire season in 2013 (T. Alsbury personal communication, July 18, 2014).

As described in NMFS (NMFS 2010; 2011d), the operation of the weirs have potential negative effects such as weir rejection, migration delay, and delayed trapping and handling mortality. NMFS expects these effects to be reduced by using proper weir location, using proper weir and trap design, using trained personnel, removing debris, preventing poaching, holding fish for the shortest time possible, and quickly processing any fish not needed for broodstock to allow for recovery and release.

As described in Section 2.4.2.2, it is difficult to readily measure impacts from weir operation, though indirect observations can be made. One indirect way to evaluate weir operations would be to observe changes in spawning distribution which may indicate weir rejection. Analysis in Section 2.4.2.2 showed there were some minor differences in redd distribution as compared to the pre-weir time period and that these differences could be due to weir operation but were more likely to be due to changes in spawning habitat. ODFW will continue to conduct spawning ground surveys to monitor effects on naturally spawning spring Chinook salmon to determine if impacts and changes in spawning distribution occur due to weir rejection. NMFS concurrence with the HGMP will include the requirement to monitor and report annually on the extent of these effects.

The acclimation of hatchery spring Chinook salmon at the Sandy Hatchery and now at the Bull Run acclimation pond is beginning to show success in reducing the number of hatchery spring Chinook salmon in the primary spawning areas in the upper Sandy River, as illustrated by returns to the Sandy Hatchery in 2013 and to the Bull Run weir so far in 2014. It is expected that as the majority of the hatchery spring Chinook salmon returning to the basin are from juveniles acclimated and released at the Bull Run acclimation pond this trend will continue.

In addition to the spawning ground surveys, in 2013, ODFW conducted snorkel surveys below the weirs to monitor adult abundance, check the integrity of the weir, and as a means to monitor migration delay. As describe in Section 2.4.2.2, the snorkel surveys below the Salmon River weir observed an increase in the number of adults below the weir but did not see a corresponding increase in passage at the weir during the following week. This may be an indication of delay, but further evaluation showed that this increase corresponded with past increases in movement towards the upper basin spawning grounds and to a decrease in flow in the mainstem Sandy River (adult spring Chinook salmon were moving out of the Sandy River to avoid high silt levels) (Whitman et al. 2014). In addition, the delay in passage also corresponded with a decrease in flows during that week and passage responded to increased flows the following week (Figure 17). Changes in the date of first spawning and peak spawning date may also indicate migration delay due to the operation of the weirs. The analysis in Section 2.4.2.2 showed that, in 2013, the date of first spawning was in the range observed before the weirs were in operation, and the peak spawning date was earlier that what was observed in the past, but this was most likely due to the major storm event that occurred in late September.

The Proposed Action includes the collection of up to 42 natural-origin male spring Chinook salmon for broodstock (see Section 1.3.1). In Section 2.4.2.1, NMFS analyzes the potential impacts from removing 42 natural-origin male spring Chinook salmon for broodstock and determined that it is not expected to reduce survival and recovery of the Sandy River spring Chinook salmon population. For example, data for the Sandy River in 2012 and 2013 show that

male natural-origin spring Chinook salmon handled at the Zigzag River and Salmon River weirs made up 59.5% of the natural-origin population above the weirs. Using these data, the removal of 22 males to produce a release of 132,000 smolts would decrease the proportion of male spring Chinook salmon from 59.5% to 58.9%. The removal of 42 males to produce a release of 300,000 smolts, would decrease the proportion of natural-origin males on the spawning grounds from 59.5% to 58.3%. This decrease in the proportion of male spring Chinook salmon in the naturally spawning population is not expected to have a noticeable effect on the productivity of the Sandy River spring Chinook salmon population.

As described in Section 2.4.2.2, the handling of adults at the weirs in 2013, resulted in only two known mortalities: one natural-origin adult at the Salmon River weir and one hatchery adults at the Bull Run weir. No mortalities were observed in 2012 (Schroeder et al. 2013). Pre-spawning mortality may be an indicator of delayed mortality due to the handling of adults at the traps. Schroeder et al. (2013) did not observe any increases in pre-spawning mortality relative to the period before weir operation, and they also concluded that the pre-spawning mortality for natural-origin spring Chinook salmon was no different above or below the weir, but did observe that it was two times higher below the weir for hatchery spring Chinook salmon. The spawning surveys in 2013 observed similar results for hatchery spring Chinook salmon as in 2012, including a higher pre-spawning mortality below the weirs. The high pre-spawning mortality for hatchery spring Chinook salmon reduces hatchery spring Chinook salmon pHOS and increases the probability of matings between natural-origin adults and reduces pHOS to a lower “effective” pHOS in the upper Sandy River Basin.

The operation of the weirs can have adverse impacts on the natural-origin population but monitoring in 2012 and 2013 has not shown these to be occurring, and the operation of the weirs have proven to be beneficial by allowing the removal of hatchery spring Chinook salmon and therefor reducing pHOS. Under the Proposed Action these activities will continue to occur increasing the confidence that the pHOS goal can be maintained over time. The long term effect of lower pHOS for the Sandy River spring Chinook salmon population is increased diversity and productivity.

A take of ESA-listed Chinook salmon will result from ME&R activities that are a requirement in this opinion to evaluate ecological interactions between juvenile hatchery salmon and steelhead and natural-origin juveniles. ODFW is expected to handle up to 1,000 juvenile Chinook salmon, 1,000 juvenile coho salmon, and 100 juvenile steelhead (Table 2). In 2013, during juvenile outmigration monitoring, a total of 320 Chinook, 200 coho, and 3 steelhead natural-origin juveniles were handled and the Chinook and coho salmon were all young of the year (age-0) juveniles (Alsbury 2013b). Juveniles were only sampled to determine origin and species and thus no mortalities were observed in 2013 (Alsbury 2013b). At the proposed level of sampling, impacts on the ESA-listed Sandy River salmon and steelhead populations are expected to be negligible. Chinook salmon juveniles are not encountered at the rotary screw trap operated in Cedar Creek because spring Chinook salmon spawning and rearing habitat is not present in the tributary.

NMFS analyzed the remaining factors (hatchery fish in the migration corridor; construction, operation and maintenance of the hatchery facilities; and fisheries) and determined that they

would have negligible or inconsequential effects on the Sandy River spring Chinook salmon population, as described in Section 2.4.2.

When hatchery fish emigration is delayed, interactions that disadvantage listed species may occur in juvenile rearing areas. ODFW will implement the following best management practices (BMP) 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, continuing to mark all hatchery juveniles, and acclimating hatchery juveniles prior to release. All of these BMPs not only reduce impacts on natural-origin juveniles, they can increase the survival of the hatchery releases thus increasing their contribution to fisheries and, achieving mitigation goals. Monitoring juvenile outmigrants at the rotary screw trap in the lower Bull Run River has shown that after the initial releases of hatchery spring Chinook salmon smolts, less than 2% of all the smolts released were encountered at the trap two days after release. This means hatchery fish leave the system promptly and there is little interaction with ESA-listed fish from Sandy River natural populations. ODFW will continue to monitoring for the presence of hatchery juveniles in the lower Sandy River as part of the juvenile outmigration monitoring and results will be reported annually (see Section 2.10.4).

Another potential threat is density-dependent interactions in the Columbia River migration corridor, the Columbia River estuary, and in the Pacific (i.e., density-dependent effects) which are not detectable, at least at this time, based on available scientific information. As discussed above, the proposed action is unlikely to cause any density dependent effects, given the magnitude of the corridor compared to the hatchery populations at issue. NMFS will monitor emerging science and information related to these interactions.

Regarding species recovery, the Recovery Plan (ODFW 2010) identified a number of limiting factors and threats to the recovery of the Sandy River Chinook salmon population, including water quality, sediment routing dysfunction, blocked and impaired fish passage, degraded floodplain and channel structure, and hydrologic alterations (see Section 2.2). None of these factors will be affected, in any measureable way, by the Proposed Action.

Applying the VSP parameters used by McElhany et al. (2007) to the Sandy River spring Chinook salmon population, the effects of the Proposed Action will be to reduce the abundance of the naturally spawning population due to the removal of natural-origin adults for broodstock, however, this is not expected to have an effect on the productivity of the population because only male spring Chinook salmon will be used and no more than 2% of the population would be removed in a single year. The productivity of the population is not expected to be adversely affected by the Proposed Action and may even increase as the impacts from the past releases of Clackamas Hatchery spring Chinook salmon decline, along with the reduction in the number of hatchery spring Chinook salmon spawning naturally, and the continued efforts to improve habitat in the basin.

The diversity parameter for the Sandy River spring Chinook salmon population is not expected to change under the Proposed Action and would be expected to improve. The PNI element is expected to decline to a low in 2016 when adults from broodyears 2011, 2012, and 2013 make up the returning adults, but under the Proposed Action, with the inclusion of natural-origin adults

into the broodstock, this element is expected to increase to levels that meet or exceed those needed for high persistence (i.e., PNI >0.67). The hatchery introgression element is expected to improve with the elimination of the Clackamas Hatchery spring Chinook salmon releases and the continued use of the locally-derived broodstock program. The synthetic approach element has already shown improvement, with pHOS declining to 9.3% in 2013. Under the Proposed Action the operation of the hatchery program is designed to minimize pHOS to levels such that it would not reduce the score for this element. Other elements for the diversity parameter are not expected to change as a result of the Proposed Action, and thus the overall score for the diversity parameter is not expected to decline and may actually increase.

The Proposed Action is not expected to affect the spatial distribution parameter. The recent observations of redd distribution have shown that there is little if any impact from the operation of the weirs and that any differences between annual redd distribution, compared to before the weirs were installed, fall within normal variability that tends to be driven by changes in the habitat quality. Based on the discussion above, the effect of the Proposed Action on the overall status of the Sandy River spring Chinook salmon population is expected to be minor, and in combination with past actions is expected to improve the status of the population by increasing productivity and abundance as well as diversity.

What does this mean for the strata and LCR Chinook Salmon ESU? Under NMFS' LCR Recovery Plan (NMFS 2013c), the Sandy River spring Chinook salmon population was identified as one of the populations in the Cascade strata that needed to be at high viability or a high persistence level (3) for the Cascade spring Chinook salmon strata to be viable and thus for the LCR Chinook salmon ESU to be viable. The quality of Sandy River spawning habitat is the reaches above the former Marmot Dam site is a key factor to recovery. Recently the Sandy River population was considered to be at moderate viability with moderate scores for abundance and productivity, spatial distribution, and diversity (NMFS 2013c). Spatial distribution has been maximized for spring Chinook salmon, with the removal of Little Sandy River diversion dam and restoration of flows in the lower Little Sandy River, but the full effects of the recovery of this habitat are only beginning to be realized. But spatial distribution will never reach historical levels due to the loss of habitat above the Bull Run water supply dams.

Under the Proposed Action, diversity is expected to increase and may reach high viability as the effects of the Clackamas Hatchery spring Chinook salmon stock releases diminish, pHOS levels remain below the 10% goal, and PNI improves to 0.67 or greater. Improvements in diversity, the reduction in pHOS and the reduction in the number of juveniles released are all expected to increase the productivity of the natural population, which would lead to increased abundance. The operation of the weirs, as proposed, do not appear to be negatively impacting the productivity of the natural population, based on recent observations, and may actually be enhancing it by decreasing pHOS. Increases in productivity and abundance ensures that the population will be better able to withstand stochastic events, (e.g., floods, fires, mudslides, El Niño, climate change) and increases NMFS confidence that the population will remain viable throughout the duration of the Proposed Action. Improvements in the viability of the Sandy River spring Chinook salmon population will accrue to the viability of the Cascade spring Chinook salmon strata and ultimately to viability of the LCR Chinook salmon ESU as a whole. Based on the best available science and in NMFS' opinion, the Proposed Action would not

appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the LCR Chinook Salmon ESU.

2.6.2. LCR Coho Salmon

NMFS believes the proposed action will adequately contain effects on natural-origin LCR coho salmon, and that the status of the ESU will not be undermined in the process. As discussed above, we find that the hatchery coho salmon in the Sandy River are no more than moderately diverged from the natural-origin population, that straying of hatchery fish has not damaged the prospects for recovery, and that the program going forward includes adequate safeguards to assure that straying will be limited in a way that continues to adequately contain the risk of hatchery effects.

Take effects analysis shows little risk to the ESU as a result of the Proposed Action. NMFS analyzes seven factors to determine the effects of a hatchery program on ESA-listed species and on designated critical habitat (Section 2.4.2). The amount and effect of the take on the ESA-listed coho salmon, as detailed in Section 2.4, are summarized below; for the majority of the activities where take occurs, NMFS found that the effects are expected to be negligible, except for take associated with broodstock collection, hatchery adults spawning naturally, and ME&R activities (Table 2). None of the hatchery factors that NMFS analyzed for effects are a known or likely threat to the Sandy River coho salmon population or to the LCR Coho Salmon ESU (see Section 2.4.2). In fact, the LCR salmon and steelhead recovery plan (ODFW 2010) did not identify hatchery actions as a factor limiting coho salmon survival and recovery.

NMFS determined that the Sandy Hatchery coho salmon program was no more than moderately diverged from the natural population in the Sandy River Basin and that the stock was derived from the local, native 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. NMFS 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). Under these circumstances, NMFS considers the hatchery stock to be integrated with the related natural population.

Under the Proposed Action, the effects of straying do not pose a substantial risk to the ESU. Within the population, historically until 1999 Sandy River natural-origin coho were incorporated into the broodstock but at a very low rate, this and the very low numbers of hatchery coho salmon trapped at Marmot Dam indicate that effects of straying have been minimal. Beginning in 1999, only marked hatchery coho salmon were used for broodstock and as a result limiting pHOS has become more critical. In the intervening years since the removal of Marmot Dam basin-wide surveys and estimated that pHOS has fluctuated between 0-12%.

Under the Proposed Action, the coho salmon HGMP includes a strict standard for pHOS and includes monitoring and reporting requirements to verify compliance with the standard. The standard for pHOS is <5% for the coho salmon hatchery program. This pHOS goal is less than the 10% that was included in the Oregon's Recovery Plan (ODFW 2010). Potential genetic impacts from hatchery-influenced selection are expected to be minimal when the pHOS goal of <5% is achieved. The reason that the pHOS goal for the coho salmon hatchery program is <5%,

even though the hatchery program was derived from the Sandy River coho salmon population, is due to the use of only hatchery adults in the broodstock since 1999 when the first marked hatchery adults began to return. This is a very conservative and protective standard because fish in the hatchery program are not substantially diverged from the coho salmon natural population and are included in the ESA-listed ESU and because NMFS considers genetic resources in the hatchery that represent the evolutionary legacy of the natural population to be integrated with the natural population. The pHOS standard for an integrated hatchery under HSRG guidelines is 10%.

To achieve the <5% pHOS goal, releases at the Sandy Hatchery have been reduced from over 500,000 annually to 300,000 beginning with the 2011 broodyear. All of the production for the coho salmon released into Cedar Creek will be reared entirely at the Sandy Hatchery, and this is expected to maximize homing and returns to the Sandy Hatchery. Coho salmon returning to the Sandy Hatchery may be delayed in entering Cedar Creek before fall rain increase flows in Cedar Creek. However, the hatchery coho salmon do not tend to stray into the upper basin as indicated by the small numbers of hatchery coho salmon trapped at Marmot Dam (ODFW 2013c). In the 2012 return year (October 2012 through January 2013), the pHOS estimate was 2.8% with an estimate return of 1,162 hatchery and natural-origin adults (Table 5). The pHOS in 2013 of 11.8% was from a release of around 463,000 smolts.

Despite the rise in pHOS in 2013, NMFS is confident that the risk of hatchery-influenced selection has remained low during this time. The actual effective pHOS in 2013 was probably less because most of the marked hatchery fish were observed in the lower Sandy River tributaries of Trout Creek and Gordon Creek, and 96% of the estimated abundance came from the upper basin areas where pHOS was estimated to be 5%. If the pHOS estimate was weighted based on the abundance in each area sampled, then the overall or “effective” pHOS would have been around 7% (Eric Brown, ODFW, personal communication). NMFS as part of its written approval will require that ODFW monitor spawning escapements to determine if the pHOS goal is being achieved. Moreover, 2013 represents and earlier point in the implementation of the risk reduction measures discussed above. The program’s strategy for controlling pHOS will likely be more effective, on top of the fact that pHOS has been low in most years prior to 2013. Combined with the lower effective pHOS due to the distribution of hatchery coho salmon in the Sandy River Basin, NMFS has determined that the Proposed Action will effectively limit the risk associated with hatchery-influenced selection.

Natural-origin coho salmon will be handled during collection of broodstock at the Sandy Hatchery. Under the Proposed Action, natural-origin adults will not be used for broodstock. The adult weir in Cedar Creek will be operated to collect coho salmon broodstock. ODFW estimates that up to 600 natural-origin coho salmon could be collected, sampled, and passed above the hatchery annually. In return year 2012-13, a total of 43 natural-origin coho salmon were passed above the hatchery weir. In 2013-14 a total of 177 unmarked coho salmon were passed above the hatchery weir. The collection of natural-origin coho salmon is necessary to ensure the capture and removal of hatchery coho salmon that return at the same time as the natural-origin adults. ODFW proposes to manage the area above the hatchery weir for natural production by preventing hatchery adults from passing above the hatchery. The low expected mortality of 2% of the adults handled is not expected to limit coho salmon survival or recovery in Cedar Creek.

Natural-origin coho salmon will also be handled at the weirs used to trap and remove hatchery spring Chinook salmon. ODFW proposes to handle up to 50 natural-origin coho salmon with an estimated 2 adult mortalities (Table 2). Handling mortalities are expected to be low because the trapping occurs in October when water temperatures are lower further reducing the risk to coho salmon collected at the weirs. The spring Chinook salmon weirs are generally in operation into early October and it is at this time that they may trap coho salmon. In 2013, a total of 37 unmarked and 1 hatchery coho salmon were handled at the weirs with no observed mortalities (Lackey et al. 2013). The hatchery coho salmon was not passed above the weir.

As part of the ME&R activities, ODFW proposed to operate a rotary screw trap in Cedar Creek above the hatchery to monitor coho salmon and winter steelhead juvenile outmigration from Cedar Creek (see Section 1.3.5). ODFW anticipates that up to 5,000 coho salmon juveniles would be collected annually and up to 200 could be tagged for evaluation (Table 2). The rotary screw trap will be used to evaluate juvenile production to determine if natural-origin coho salmon and winter steelhead are successfully recolonizing habitat above the Sandy Hatchery in Cedar Creek. Less than 35 winter steelhead and 50 coho salmon juvenile mortalities are expected annually. In 2013, the first year of operation, the rotary screw trap handled 376 coho salmon and 14 steelhead smolts and 44 coho salmon fry (<70 mm), and 78 steelhead fry (Strobel 2014). The only mortalities were two coho salmon smolts and 2 coho salmon fry. At this level of impact that proportion of the ESA-listed population occurring in Cedar Creek is not expected to be adversely affected. Take of ESA-listed coho salmon juveniles will also occur during juvenile outmigration monitoring and the effect on the Sandy River coho salmon population from the ME&R activity is expected to be minimal (see Section 2.4.2.5). The long term monitoring of juvenile production in Cedar Creek will provide essential data on the productivity of coho salmon in this tributary that can be used to evaluate the larger Sandy River coho salmon population.

When hatchery fish emigration is delayed, interactions that disadvantage listed species may occur in juvenile rearing areas. ODFW will 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, continuing to mark all hatchery juveniles, and acclimating hatchery juveniles prior to release. ODFW will continue monitoring for the presence of hatchery juveniles in the lower Sandy River as part of the juvenile outmigration monitoring and results will be reported annually (see Section 2.10.4).

Another potential threat is density-dependent interactions in the Columbia River migration corridor, the Columbia River estuary, and in the Pacific (i.e., density dependent effects) which are not detectable, at least at this time, based on available scientific information. As discussed above, the proposed action is unlikely to cause any density dependent effects, given the magnitude of the corridor compared to the hatchery populations at issue. NMFS will monitor emerging science and information related to these interactions.

Regarding species recovery, the Recovery Plan (ODFW 2010) also identified a number of limiting factors and threats to the Sandy River coho salmon population, including water quality, sediment routing dysfunction, blocked and impaired fish passage, degraded floodplain and

channel structure, and hydrologic alterations (see Section 2.2). None of these factors will be affected, in any measureable way, by the Proposed Action.

Applying the VSP parameters used by McElhany et al. (2007) to the Sandy River coho salmon population, the effects of the Proposed Action are not expected to reduce the abundance of the naturally spawning population because natural-origin coho salmon will not be used for broodstock. Adult abundance may be reduced due to mortality from handling of natural-origin adults encountered at the weirs, but this is expected to be negligible based on recent data that shows that no known mortalities have occurred due handling at the weirs. The Proposed Action is not expected to affect the abundance of individual coho salmon cohorts, which will continue to be impacted by habitat constraints and impacts outside the Action Area. The productivity of the population may increase if the pHOS goal of 5% is achieved, but this increase may not be measurable compared to the previous pHOS goal of <10%. Productivity of the entire population may increase due to the natural production that is now occurring in Cedar Creek above the hatchery, and in the Little Sandy River. These areas were not accessible prior to the evaluations by McElhany et al. (2007) and Ford (2011). Productivity may also increase due to the removal of Marmot Dam and the elimination of impacts on juvenile migrants at the dam.

The diversity parameter is not expected to change under the Proposed Action. The life history traits element is not expected to change, though the removal of Marmot Dam and the access to the Little Sandy River and Cedar Creek may lead to the expression of a greater diversity of life histories. The operation of the Sandy Hatchery coho salmon program is not expected to have an effect on the effective population size, with natural-origin coho salmon escapement expected to continue to be above 500 adults annually. The PNI element does not apply to this program because natural-origin adults are not used in the broodstock. The hatchery introgression element is not expected to change because the Sandy Hatchery coho salmon program was derived from the Sandy River coho salmon population, and has not diverged to the point where the hatchery coho salmon would not be considered to be part of the MPG or the LCR Coho Salmon ESU (NMFS 2003b; 2004b; Jones 2011), though this will need to be monitored over the long-term due to the use of only returning hatchery coho salmon for broodstock. The synthetic approach element is expected to improve as lower pHOS goals are met due to the reduction in the number of smolts released, and the full-term rearing of the coho salmon at the Sandy Hatchery. Other elements for the diversity parameter are not expected to change as a result of the Proposed Action, and thus the overall score for the diversity parameter is not expected to decline and may even increase.

Recent reviews by the California HSRG (2012) and the HSRG (2014) identified that segregated programs, even at 5% pHOS, may not be as protective over the long term to the natural-origin population than that provided by an integrated program. The current Sandy Hatchery coho salmon program is part of the LCR Coho Salmon ESU, because it is only moderately diverged from the natural population and thus could be used as gene bank and supplement the natural population if the population is catastrophically impacted. NMFS is concerned that without the incorporation of natural-origin adults in the hatchery broodstock that the hatchery population may become more than moderately diverged from the natural-origin population, and thus may pose a greater threat to, and may not be suitable as a gene bank for the natural-origin coho salmon population in the Sandy River. Because of these two issues, NMFS will work with

ODFW to determine if natural-origin coho salmon should be incorporated into the broodstock in the future.

The Proposed Action is not expected to affect the spatial distribution parameter. Natural-origin coho salmon will continue to be released above the hatchery weir into Cedar Creek, maintaining the current spatial distribution. The operation of the weirs to collect spring Chinook salmon are not expected to affect the spatial distribution of natural-origin coho salmon because the operation of the weirs would only impact those coho salmon encountering the weirs in early October, and the weirs are generally removed prior to coho salmon spawning. Based on the discussion above, the effect of the Proposed Action on the overall status of the Sandy River coho salmon population is expected to be minor, and in combination with past actions may even improve the status of the population. Rolling this determination up to the MGP and ESU levels, the Proposed Action is not expected to reduce the likelihood of survival and recovery of the LCR Coho Salmon ESU, because the proposed hatchery program is expected to reduce impacts on the Sandy River coho salmon population, allowing that population to support the recovery of the entire ESU.

What does this mean for the strata and LCR Coho Salmon ESU? Under NMFS' LCR Recovery Plan (NMFS 2013c), the Sandy River coho salmon population was identified as one of the populations in the Cascade strata that needed to be at high viability or a high persistence level (3) for the Cascade coho salmon strata to be viable and thus for the LCR Coho salmon ESU to be viable. Recently the Sandy River coho salmon population was considered to be at very low viability, with very low scores for abundance and productivity, high scores for spatial distribution, and moderate scores for diversity (NMFS 2013c). The high viability score for spatial distribution reflects the removal of Marmot Dam and the diversion dam on the Little Sandy River and the restoration of flows in the lower Little Sandy River. The increased spatial distribution also includes that additional habitat now available in upper Cedar Creek above the Sandy Hatchery.

The moderate score for diversity is expected to improve under the Proposed Action as pHOS declines due to the overall reduction in the number of hatchery coho salmon smolts released and targeting the pHOS goal at < 5%. Diversity will have to be monitored closely because of concerns that even though the hatchery program is derived from the local population and pHOS is expected to be low, the long-term risks due to hatchery-influenced selection are greater for a hatchery program that does not infuse natural-origin fish into the hatchery broodstock (California HSRG 2012; HSRG 2014).

Abundance and productivity are the parameters that are limiting the viability of the Sandy River natural-origin coho salmon population. The Sandy River coho population is made up of three cohorts with little overlap between them, because of this, the annual abundance needs to be higher than for other salmonid species which have multiple ages at return. Environmental conditions can affect each cohort differently as reflected by the changes in the abundance of the three Sandy River coho salmon cohorts between the time of the status review and 2013 (Table 2). Under the Proposed Action productivity would be expected to increase because smolt releases have substantially declined, pHOS remains low, especially in the primary natural production areas, and from the elimination of the impacts associated with Marmot Dam and the Little Sandy

River diversion dam. As productivity increases, abundance is expected to increase as well. Increases in productivity and abundance ensures that the natural population will be better able to withstand stochastic events, (e.g., floods, fires, mudslides, El Niño, and climate change) and increases NMFS confidence that the population will remain viable throughout the duration of the Proposed Action. Improvements in the viability of the Sandy River coho salmon population will accrue to the Cascade strata and ultimately to the viability of the LCR Coho Salmon ESU as a whole. Based on the best available science and in NMFS' opinion, the Proposed Action would not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the LCR Coho Salmon ESU.

2.6.3. LCR Steelhead

NMFS believes the proposed action will adequately contain effects on natural-origin LCR steelhead, and that the status of the DPS will not be undermined in the process. As discussed above, we find that the hatchery summer and winter steelhead in the Sandy River are straying at rates that do not threaten the natural-origin winter steelhead population in the Sandy River, and that the program going forward includes adequate safeguards to assure that straying will be limited in a way that continues to adequately contain the risk of hatchery effects. In addition, the hatchery winter steelhead is minimally diverged from the natural-origin component, and included as part of the ESA-listed DPS. Maintaining this factor through incorporation of natural-origin broodstock will further minimize the risk posed by the program.

Take effects analysis shows little risk to the ESU as a result of the Proposed Action. NMFS analyzes seven factors to determine the effects of a hatchery program on ESA-listed species and on designated critical habitat (Section 2.4.2). The amount and effect of the take on the ESA-listed winter steelhead, as detailed in Section 2.4, are summarized below; for the majority of the activities where take occurs, NMFS found that the effects are expected to be negligible, except for take associated with broodstock collection, hatchery adults spawning naturally, and ME&R activities (Table 2). None of the hatchery factors that NMFS analyzed for effects is a known or likely threat to the Sandy River winter steelhead population or to the LCR Steelhead DPS (see Section 2.4.2). However, based on past levels of pHOS, the LCR salmon and steelhead recovery plan (ODFW 2010) identified hatchery fish spawning naturally as a factor limiting winter steelhead survival and recovery. It should be noted that several recommendations in the recovery plan for addressing limiting factors are included in the HGMP.

NMFS has determined that the Sandy River hatchery winter steelhead are no more than minimally diverged from the natural-origin population. This determination is based on the best scientific information available, that shows that the hatchery program was initiated used only natural-origin Sandy River winter steelhead and that the natural-origin winter steelhead have been incorporated into the broodstock (until the last three years) at levels such that there is no appreciable genetic difference between the hatchery spring Chinook salmon and the natural-origin population (NMFS 2003a; 2004b).

NMFS expects the Proposed Action to control straying of hatchery-origin steelhead to levels that minimize risk to the natural-origin population. To address hatchery-influenced selection due to hatchery adults spawning naturally, the winter steelhead HGMP includes a pHOS goal of <10% for winter steelhead and <5% for summer steelhead, and includes monitoring and reporting

requirements to verify compliance with the standards. The reasoning behind NMFS' support of the <10% pHOS goal for spring Chinook salmon, as described in Section 2.4.2.2, is also applicable to the Sandy River winter steelhead hatchery program. The recycling of hatchery winter steelhead to provide additional harvest opportunities may increase hatchery adults on the spawning grounds. Under the Propose Action (see Section 1.3.3) recycling winter steelhead would be discontinued if monitoring shows that the <10% pHOS goal is not being achieved.

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 surveys were conducted in 2010, 2011, and 2012. Abundance and pHOS estimates were based on very small sample sizes, so may have been imprecise. For example, the 2010 pHOS estimate of 29% was based on 7 live adults being observed with 2 being clipped. The 2011 and 2012 estimates of 0% pHOS were based on 19 and 3 live winter steelhead observed, all with adipose fins, respectively, which likely underestimated pHOS. In 2013, the sampling and spawning survey program was expanded with goal of increasing sample sizes (i.e., the number of known-mark adults that were observed) and this was expected to result in greater confidence in the accuracy of the pHOS and abundance estimates. Data for 2013 indicate that the total runsize for winter steelhead was 3,747 adults of which 3,509 were natural-origin and 238 were hatchery origin (ODFW 2013g). The pHOS estimate of 6.4% was based on total of 47 observed known-mark winter steelhead.

Potential genetic impacts from outbreeding depression are expected to be minimal for the summer steelhead program when the pHOS goal of < 5% is achieved. The summer steelhead released into the Sandy River are not endemic to the Sandy River and thus the more restrictive pHOS goal of < 5%. To achieve this pHOS goal summer steelhead are acclimated and released at the Sandy Hatchery. The release of hatchery summer steelhead from the Sandy Hatchery has been successful in separating returning hatchery summer steelhead adults from the naturally spawning winter steelhead population, based on observations at the two weirs in the upper Sandy River Basin. In 2012, two unmarked and zero clipped summer steelhead were observed (Zweifel 2013), and in 2013, four unmarked and zero clipped summer steelhead were observed. The recycling of hatchery summer steelhead to provide additional harvest opportunities may increase hatchery adults on the spawning grounds (Lackey et al. 2013). Under the Proposed Action (see Section 1.3.3), recycling summer steelhead would be discontinued if monitoring shows that the 5% pHOS goal is not being achieved.

The pHOS goal of < 5% is achievable because there is very little overlap between the spawn timing of summer steelhead from the South Santiam Hatchery and natural-origin Sandy River winter steelhead. South Santiam Hatchery broodstock spawning tends to be over by the end of February before Sandy River winter steelhead spawning generally commences. The separation between summer steelhead and late-run winter steelhead was confirmed by other research that showed that interbreeding between these two groups was minimal even at high summer steelhead abundance (Leider et al. 1984; Kostow et al. 2003).

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). Using this method, all hatchery-origin spawners in February are assumed

to be 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, 2 steelhead were observed in February during the 2010 winter steelhead spawning survey, one with an ad-clip and one unclipped, yielding a pHOS estimate for February of 50% (0.5). During that survey season, a total 231 redds were observed, 2 of them in February. The summer steelhead pHOS estimates for that survey season was thus 0.43% (0.5 x 2/231). Using this same method, in 2012 and 2013 all of the steelhead observed in February were unmarked and thus pHOS for summer steelhead was zero.

Compared to salmon, steelhead are difficult to enumerate on the spawning grounds because of their protracted spawning period and the time of year when they spawn, so monitoring methods are typically not as refined as we would wish. However, the current method is conservative, resulting more likely in overestimates of summer steelhead pHOS than underestimates. Furthermore, ODFW, when conducting coho spawning surveys from October through January, will also record steelhead observations, both live adults and redds. Very few steelhead have been observed during the coho surveys even though approximately 56% of the habitat surveyed during coho spawning surveys overlaps with winter steelhead habitat. These surveys can provide information on whether or not summer steelhead are spawning prior to the month of February. Given the fact that the current method to estimate summer steelhead pHOS is likely over estimating pHOS, it is NMFS's opinion that this monitoring method will be adequate to ensure that the pHOS criterion is being met. Based on recent experience, NMFS concludes that these gene flow criteria can and will be met, and it is therefore NMFS' opinion that the genetic impact of this program will not pose a survival or recovery risk to the natural-origin Sandy River winter steelhead population.

The Proposed Action includes the collection of up to 26 natural-origin male winter steelhead for broodstock (see Section 1.3.3). In Section 2.4.2.1, NMFS analyzes the potential impacts from removing 26 natural-origin male winter steelhead for broodstock and determined that it is not expected to reduce survival and recovery of the Sandy River winter steelhead population. ODFW completed a quantitative PVA that indicated the maximum rate of impacts on the Sandy River winter steelhead population was 30%, but ODFW set a maximum fisheries impact limit of 20%, under the conservative assumption that this would provide a reasonable cushion for errors, even though the model results suggest that management under a 40% 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% of the natural-origin Sandy River winter steelhead population annually (ODFW 2003c). The less than 2% impact from the removal of 26 male natural-origin winter steelhead in addition to the impacts from the freshwater fisheries is expected to be less than 5% which is substantially below the maximum impact limit of 20%. Furthermore, natural-origin winter steelhead used for broodstock will be live-spawned once and released back into the Sandy River to potentially spawn again. As a result, the impacts from the proposed use of male natural-origin winter steelhead should not adversely affect the Sandy River winter steelhead population. This level of natural-origin adults in the broodstock and maintenance of a <10% pHOS will minimize impacts on the ESA-listed winter steelhead population as well as meet the HSRG's PNI guidelines for a population of high conservation value (one with high persistence or very low risk of extinction).

Natural-origin winter steelhead will be handled during collection of broodstock at the Sandy Hatchery. The adult weir in Cedar Creek will be operated to collect winter steelhead broodstock, diverting all returning steelhead (both summer and winter) migrating up Cedar Creek into the hatchery. ODFW estimates that up to 200 natural-origin winter steelhead could be collected, sampled, and passed above the hatchery annually. In 2013, a total of 20 natural-origin winter steelhead were passed above the hatchery and in 2014 the total passed was 24. The trapping of natural-origin winter steelhead at the hatchery is necessary to ensure the capture and removal of hatchery winter steelhead that return at the same time as the natural-origin adults. ODFW proposes to manage the area above the hatchery weir for natural production by preventing hatchery summer and winter steelhead adults from passing above the hatchery. The expected low mortality of 2% of the adults handled would not be expected to limit winter steelhead survival or recovery in Cedar Creek.

Under the Proposed Action, no-hatchery winter steelhead will be passed above the hatchery for a period of five years (2019), at which time the success of the recolonization of upper Cedar Creek by natural-origin winter steelhead will be evaluated. The productivity in Cedar Creek will be monitored using a rotary screw trap to collect juvenile outmigrants (see Section 1.3.5). If returns and productivity estimates based on the juvenile monitoring show that the these releases are not fully seeding the habitat, ODFW will devise a plan to supplement the natural population with returning hatchery winter steelhead and submit that plan for NMFS approval. The integration of the winter steelhead program with natural-origin adults allows this program to act as a safety-net for that proportion of the Sandy River population that spawns in Cedar Creek.

Steelhead may also be handled during the trapping of hatchery spring Chinook salmon at the weirs operated in the basin. ODFW proposes to handle up to 200 natural-origin steelhead, and will sample all natural-origin steelhead trapped at the Bull Run weir. The steelhead handled at the tributary weirs would primarily be unmarked summer steelhead and these are assumed to be mis-marked hatchery summer steelhead, offspring of hatchery summer steelhead that spawned naturally or strays from other Columbia River summer steelhead populations. An estimated 5 adult steelhead mortalities may occur due to handling (Table 2). All unmarked steelhead trapped at the Bull Run weir will be genetically sampled for future analysis to determine their origin and released downstream of the weir. All summer steelhead collected at the upper basin weirs will be released downstream in the lower Sandy River. These fish will not have access to important natural spawning areas for winter steelhead. The weirs are generally in operation from late June into early October and are not expected to encounter Sandy River winter steelhead because winter steelhead do not return to the basin until well after the weirs are removed. In 2012, two unmarked and zero marked summer steelhead were observed at the weirs, and in 2013, four unmarked and zero clipped summer steelhead were observed at the upper basin weirs, and 20 unmarked summer steelhead (16 unmarked and one hatchery summer steelhead) were collected at the Bull Run weir (Lackey et al. 2013). No mortalities were observed.

As part of the ME&R activities, ODFW proposed to operate a rotary screw trap in Cedar Creek above the hatchery to monitor juvenile outmigration from Cedar Creek (see Section 1.3.5). ODFW anticipates that up to 3,500 juvenile steelhead could be collected and up to 500 could be tagged for evaluation (Table 2). The rotary screw trap will be used to evaluate juvenile production to determine if natural-origin coho salmon and winter steelhead are successfully

recolonizing habitat in Cedar Creek above the Sandy Hatchery. Less than 35 winter steelhead juvenile mortalities are expected annually. In 2013, the first year of operation, the rotary screw trap handled 14 steelhead smolts and 78 steelhead fry with no observed mortalities (Strobel 2014). The number of juvenile winter steelhead handled annually is expected to increase as 2 year-old smolts begin emigrating in 2014. At this level of impact, the proportion of the ESA-listed populations occurring in Cedar Creek is not expected to be adversely affected. Take of ESA-listed winter steelhead juveniles will also occur during juvenile outmigration monitoring and the effect on the Sandy River winter steelhead population is expected to be minimal (see Section 2.4.2.6).

When hatchery fish emigration is delayed, interactions that disadvantage listed species may occur in juvenile rearing areas. ODFW will 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, continuing to mark all hatchery juveniles, and acclimating hatchery juveniles prior to release. ODFW will continue to monitor for the presence of hatchery juveniles in the lower Sandy River as part of the juvenile outmigration monitoring and results will be reported annually (see Section 2.10).

Another potential threat is density-dependent interactions in the Columbia River migration corridor, the Columbia River estuary, and in the Pacific (i.e., density-dependent effects) which are not detectable, at least at this time, based on available scientific information. As discussed above, the proposed action is unlikely to cause any density dependent effects, given the magnitude of the corridor compared to the hatchery populations at issue. NMFS will monitor emerging science and information related to these interactions.

Regarding species recovery, the Recovery Plan (ODFW 2010) identified a number of additional limiting factors and threats to the Sandy River winter steelhead population, including water quality, sediment routing dysfunction, blocked and impaired fish passage, degraded floodplain and channel structure, and hydrologic alterations (see Section 2.2). None of these factors will be affected, in any measureable way, by the Proposed Action.

Applying the VSP parameters used in McElhany et al. (2007) to the Sandy River winter steelhead population, the effects of the Proposed Action will reduce the abundance of the natural-origin population due to the removal of natural-origin adults for broodstock. However, this is not expected to have an effect on the productivity of the population because only male winter steelhead will be used, no more than 2% of the population would be collected, and the male steelhead would be live-spawned once and returned to the Sandy River to potentially spawn again. The productivity of the population is not expected to be adversely affected by the Proposed Action and may even increase as the impacts from the past releases of Big Creek stock winter steelhead decline, the winter steelhead pHOS goal of <10% is achieved, and restoration actions improve habitat. Productivity of the entire population may also increase due to the natural production that is now occurring in Cedar Creek above the hatchery, and in the Little Sandy River. These areas were not accessible prior to the evaluations by McElhany et al. (2007) and Ford (2011). Productivity may also increase due to the removal of Marmot Dam and the elimination of impacts to juvenile migrants at the dam.

The diversity parameter for the Sandy River winter steelhead population is not expected to change under the Proposed Action but it could improve. The PNI element is expected to decline to a low in years 2014-2016 as returns from broodyears 2012, 2013, and 2014 make up the majority of the returning adults. However, under the Proposed Action, with the inclusion of natural-origin adults into the broodstock, this element is expected to increase to levels that meet or exceed those needed for high persistence (i.e., PNI >0.67). The hatchery introgression element is expected to improve with the elimination of the Big Creek stock winter steelhead releases and the continued use of locally-derived broodstock program. The release of summer steelhead may affect this element, but the impacts from summer steelhead on this diversity element are expected to remain low based on the observed low pHOS estimates. The synthetic approach element is expected to improve as long as pHOS remains low (i.e., 6.4% in 2013). Under the Proposed Action the operation of the hatchery program is designed to minimize pHOS to levels such that it would not reduce the score for this element. Other elements for the diversity parameter are not expected to change as a result of the Proposed Action, and thus the overall score for the diversity parameter is not expected to decline and may actually increase.

The Proposed Action is not expected to affect the spatial distribution parameter. Natural-origin winter steelhead will continue to be released above the hatchery into Cedar Creek, maintaining the current spatial distribution. The operation of the weirs to collect spring Chinook salmon are not expected to affect the spatial distribution of natural-origin winter steelhead because the weirs would not be operated when ESA-listed winter steelhead are present. The minor delay of natural-origin winter steelhead that are directed into the Sandy Hatchery is not expected to reduce spatial distribution and will ultimately provide a benefit by limiting the habitat above the hatchery to only natural-origin winter steelhead. Based on the discussion above, the effect of the Proposed Action on the overall status of the Sandy River winter steelhead population is expected to be minor, and in combination with past actions may even improve the status of the population.

What does this mean for the strata and the LCR Steelhead DPS? Under NMFS' LCR Recovery Plan (NMFS 2013c), the Sandy River winter steelhead population was identified as one of the populations in the Cascade winter steelhead strata that needed to be at a very high viability or high persistence level (>3) for the Cascade winter steelhead strata to be viable and thus for the LCR Steelhead DPS to be viable. Recently the Sandy River population was considered to be at low viability with a low score for abundance and productivity and moderate scores for spatial distribution and diversity (NMFS 2013c). Spatial distribution has been maximized, with the removal of Little Sandy River diversion dam and restoration of flows in the lower Little Sandy River, but the full effects of the recovery of this habitat are only beginning to be realized. In addition, spatial distribution has increased due to access to Cedar Creek above the Sandy Hatchery, however, spatial distribution will never reach historical levels due to the loss of habitat above the Bull Run water supply dams.

Under the Proposed Action, diversity is expected to increase and may reach high viability as the effects of the Big Creek Hatchery stock winter steelhead releases diminish, winter steelhead pHOS levels remain below the 10% goal, and the PNI improves to 0.67 or greater. The diversity parameter should not be reduced by the summer steelhead program because data show that genetic introgression is not occurring between the natural-origin winter steelhead population and naturally spawning hatchery summer steelhead.

Abundance and productivity are the parameters that were identified as limiting the viability of the Sandy River winter steelhead population. Abundance increased in 2013 to a level that has not been observed since the early 1990s (Table 5). However, a note of caution, the abundance estimated in 2013 may be an artifact of the expanded spawning ground surveys and additional years of data will be needed to determine if this is an accurate measure of abundance. Under the Proposed Action productivity would be expected to increase because of improvements in diversity, the maintenance of low pHOS (for hatchery winter steelhead and summer steelhead), from access to habitat in the Little Sandy River and upper Cedar Creek and from the elimination of the impacts associated with Marmot Dam and the Little Sandy River diversion dam. Increases in productivity and abundance ensures that the natural population will be better able to withstand stochastic events, (e.g., floods, fires, mudslides, El Nino, climate change) and increases NMFS confidence that the population will remain viable throughout the duration of the Proposed Action. Improvements in the viability of the Sandy River winter steelhead population will accrue to the Cascade winter steelhead strata and ultimately to the viability of the LCR Steelhead DPS as a whole. Based on the best available science and in NMFS' opinion, the Proposed Action would not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the LCR Steelhead DPS are all expected to increase the productivity of the natural population, which would lead to an increase in abundance.

2.6.4. Critical Habitat

Critical habitat for the ESA-listed species is described in Section 2.2.2 of this opinion. After reviewing the Proposed Action and conducting the effects analysis, NMFS has determined that the Proposed Action will not impair PCEs designated as essential for spawning, rearing, juvenile migration, and adult migration purposes. In reviewing the Proposed Action and after conducting the effects analysis (see Section 2.4.2), NMFS has determined that the Proposed Action will not impair PCEs designated as essential for spawning, rearing, juvenile migration, and adult migration purposes as described below.

The only effects on critical habitat from the proposed action would occur in freshwater migration corridors. The hatchery facility itself would not require additional construction or disturbance of riparian or streambed habitat, and any effects of water withdrawal and effluent are expected to be small and transitory. Hatchery intakes are screened to prevent fish injury from impingement or permanent removal from streams. Minimum flows will be maintained in Cedar Creek between the hatchery intake and the outfall, thus providing for adult migration through this section. The operation of the adult weir and intake structure at the Sandy Hatchery on Cedar Creek would not be expected to impact natural-origin spring Chinook salmon because Cedar Creek does not contain spring Chinook salmon spawning or rearing habitat. The upstream migration of natural-origin winter steelhead and coho salmon in Cedar Creek would be delayed because all steelhead and coho salmon are directed into the hatchery so that hatchery adults can be removed. The delay in upstream migration is expected to be short and would not adversely impact natural-origin steelhead and coho salmon. Access to habitat in Cedar Creek above the Sandy Hatchery has been provided to coho salmon and winter steelhead.

Impacts on juvenile coho salmon and winter steelhead would occur when the flow in Cedar Creek is reduced to provide water to rear the coho salmon at the Sandy Hatchery. These impacts

would be expected to be the greatest during September, when water flows in Cedar Creek tend to be at their lowest. The numbers of juvenile coho salmon and steelhead affected, if any, would be expected to be small, because water temperatures in that area become elevated during the summer months, and ODFW would maintain minimum flows that would provide for juvenile passage. Impacts would be expected to be temporary and only last until fall rains increase flows in Cedar Creek.

The effects on critical habitat of pumping water for the Bull Run acclimation pond are expected to be negligible because the pump would be screened to meet NMFS criteria, the water would be returned to the same pool where it was removed, and the pond would be operated during periods of high flows in the Bull Run River.

Habitat impacts from the installation and operation of the weirs are expected to be limited to the weir location, and to be of a limited duration. Habitat will be temporarily impacted by the placement of the weirs. Each weir is designed to be installed and removed annually, eliminating the requirement for permanent structures in the river. When the weirs are operational, they will impact the PCEs for migration as follows:

- The installation of the weirs in the Zigzag River, the Salmon River, and the Bull Run River in early June could potentially lead to the handling of the majority of natural-origin spring Chinook salmon returning to the Sandy River Basin. Monitoring associated with spawning ground surveys would be used to determine if the presence of the weirs were causing natural-origin spring Chinook salmon to spawn downstream of the weirs.
- The weirs, if installed by the first of June, may encounter winter steelhead kelts (fish that have already spawned) migrating out of the basin. The actual number of kelts 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. Winter steelhead kelts have not been observed at the weirs. Adult winter steelhead would not be expected to be encountered during weir operations because they return after the weirs are removed and before the weirs are installed.
- Impacts on coho salmon would occur on that proportion of the adult returns that enters the upper Sandy River and Bull Run River prior to the removal of the weirs. ODFW proposes to use the observed presence of coho salmon as an indicator as to when to remove the weirs for the season. Impacts are expected to be low because few coho salmon would be handled.

Indications that the handling of natural-origin adults at the weirs could contribute to pre-spawning mortality would be observed through the evaluation of carcasses recovered during spawning ground surveys. Spawning surveys in 2012 and 2013 did not identify any increase in pre-spawning mortality associated with the handling of adults at the weirs outside what had been observed prior to operation (Lackey et al. 2013; Schroeder et al. 2013). Affects associated with weirs, such as passage delay, are expected to be mitigated through proper weir design and placement, the use of trained personnel, and operations that minimize the time salmon and steelhead are held or delayed at the weirs.

The Sandy Hatchery is operated under NPDES permit #10598. Effluent from the hatchery is monitored weekly to ensure compliance with permit requirements. The Bull Run acclimation pond does not need a NPDES permit because rearing levels in the acclimation pond are below permit minimums. All of the other facilities that rear salmon and steelhead for the Sandy River programs also have NPDES permits where the effluent from the facilities are monitored weekly to ensure compliance (see Section 1.3).

Oxbow Hatchery, Bonneville Hatchery, and Oak Springs Hatchery all use spring water when rearing salmon and steelhead for the Sandy Hatchery programs, and thus their water usage would not have an impact on critical habitat.

In reviewing the effects of the proposed action on water quality and quantity, NMFS determined that the impacts from removing up to 2% of the Clackamas River flow for a short period of time in September would not be measurable and is not expected to reduce freshwater rearing habitat area or quality to the levels that would have any discernable effects on ESA-listed salmon or steelhead juveniles or adults that may be present in the area adjacent to the Clackamas Hatchery during the holding and spawning of spring Chinook salmon for the Sandy Hatchery program.

The Cascade Hatchery is used to rear Sandy River spring Chinook salmon from July through October before they are transferred to the Sandy Hatchery in November. During this period, on average about 16% of the water used at the hatchery is for the Sandy River spring Chinook salmon program. During the summer months, the hatchery reduces flow in the section of Eagle Creek from the intake at RM 0.8 to the hatchery outfall at RM 0.2, only minimal flows are provided. As described in ODFW (2002), habitat quality in this section and the area from the intake upstream to the natural falls on Eagle Creek located at RM 1.2, is very poor due to the high gradient, and limited instream large woody debris due to high velocities and frequent flooding. ODFW concluded that there was very limited rearing habitat for salmonids. NMFS did identify the habitat below the falls as spawning and rearing habitat for LCR steelhead based solely on access to this area. The reduction in flow is not expected to reduce freshwater rearing habitat area or quality to the levels that would have any discernable effects on ESA-listed salmon or steelhead juveniles or adults that may be present in the area adjacent to the Cascade Hatchery during the rearing of spring Chinook salmon for the Sandy Hatchery program.

The South Santiam Hatchery is used to hold and spawn summer steelhead that are used for the Sandy Hatchery summer steelhead program. The water intake for the South Santiam Hatchery is in Foster Reservoir and the hatchery outfall is directly in to the pool below Foster Dam and as a result the operation of the South Santiam Hatchery is not expected to reduce freshwater rearing habitat area or the quality to the levels that would have any discernable effects on ESA-listed salmon or steelhead juveniles or adults.

2.6.5. Climate Change

The Sandy River Chinook salmon, coho salmon, and steelhead populations, may be adversely affected by climate change (see Section 2.2.3). A decrease in winter snow pack would be expected to reduce spring and summer flows and increase water temperatures throughout the Sandy River Basin. Warmer temperatures may also increase the probability of higher sediment loads in the mainstem and Zigzag Rivers due to more rain-on-snow events on the upper slopes of

Mt. Hood releasing sediment that is no longer protected by winter snow pack. Reduced summer flows and higher water temperatures would be expected to reduce the habitat quality and habitat quantity needed for juvenile rearing and for adult holding, making those areas in the upper basin more essential for the persistence and recovery of the ESA-listed populations. With passage having been restored to upper Cedar Creek, there are concerns that habitat quantity and quality will be degraded in this newly accessible reach as annual flows are reduced and water temperatures increase as a result of climate change. Water temperature in the lower Cedar Creek is currently a factor limiting production in Cedar Creek, and as a result, ODFW and NMFS will monitor Cedar Creek base-flow conditions during the summer and fall low-flow periods. These climate change effects on the quantity and quality of habitat in the Sandy River Basin would be expected over the next 50 years to reduce the spatial distribution of the populations because some sections of the basin may become too warm for rearing, as well as reducing their productivity unless the natural-origin populations can adapt to these changes. The Proposed Action is not expected to add these effects on habitat quality and quantity, but could act as genetic reservoir for the ESA-listed salmon and steelhead populations in the Sandy River Basin in case of catastrophic loss of production due to climate change.

2.7. Conclusion

After reviewing the current status of the listed species, the environmental baseline within the Action Area, the effects of the Proposed Action, including effects of the Proposed Action that are likely to persist following expiration of the Proposed Action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence of the LCR Chinook salmon and LCR Coho Salmon ESUs, and the LCR Steelhead DPS, or destroyed or adversely modify designated critical habitat for LCR Chinook salmon and LCR steelhead. No critical habitat has been designated for LCR coho salmon, so none was analyzed.

2.8. Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. For purposes of this consultation, we interpret "harass" to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or significantly altered. Section 7(b)(4) and Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA, if that action is performed in compliance with the terms and conditions of this ITS.

2.8.1. Amount or Extent of Take

Take of ESA-listed salmon and steelhead would occur as a result of the Proposed Action from (1) broodstock collection, including the operation of weirs; (2) interactions on the spawning grounds; (3) interactions in juvenile rearing areas; (4) construction, operation, and maintenance of hatchery facilities; and (5) monitoring, evaluation and research (ME&R).

(1) Broodstock Collection

Handling

In the course of collecting hatchery broodstock, the proposed action authorizes the annual handling of up to 400 adult natural-origin steelhead (200 winter and 200 out-of-basin summer), 650 natural-origin adult coho salmon, and up to 3,080 adult natural-origin spring Chinook salmon (Table 2). These numbers of fish represent the quantified level of expected take associated with broodstock collection. These are fish that volunteer into the Sandy Hatchery or are trapped at weirs located throughout the Sandy River Basin; all natural-origin salmon and steelhead must be released, uninjured, immediately upstream of the weir site.

In addition to the incidental take associated with handling, there are quantified levels of take associated with the retention and collection of natural-origin spring Chinook salmon and winter steelhead for inclusion into the broodstock. Such retention represents an exception to the requirement above regarding release of natural-origin fish that volunteer to the weirs. At the current production level of 132,000 smolts, up to 22 male natural-origin spring Chinook salmon, collected at the weirs in the upper Sandy River Basin, may be retained for broodstock. In the future, up to 42 natural-origin male spring Chinook salmon, collected at the weirs in the upper Sandy River Basin, may be retained for broodstock to increase production to 300,000 smolts, this would only occur if the 10% pHOS goal is being achieved. These fish will be live-spawned once and released back into the upper Sandy River to potentially spawn again. At no time will more than 2% of the natural-origin spring Chinook salmon population be retained for broodstock. The escapement of natural-origin spring Chinook salmon will be monitored at the weirs to ensure that the spring Chinook salmon escapement is such that broodstock collection will not exceed 2% of the natural-origin population.

Separate from the take by handling at the hatchery weir, up to an additional 26 male natural-origin winter steelhead may be collected and retained for broodstock. These natural-origin adults will be collected using hook and line. These fish will be live-spawned once and released back into the Sandy River to potentially spawn again. At no time will more than 2% of the natural-origin winter steelhead population be retained for broodstock. The escapement of natural-origin winter steelhead will be monitored during winter steelhead spawning surveys to ensure that the winter steelhead escapement is such that broodstock collection will not exceed 2% of the natural-origin population.

ESA-listed hatchery-origin steelhead, spring Chinook salmon, and coho salmon, and non-listed summer steelhead that volunteer at weir locations shall not be returned to the river; consequently, up to 100% of ESA-listed hatchery-origin adult spring Chinook, coho and winter steelhead encountered at the weir will be taken by handling, collection and/or retention. Hatchery winter

steelhead and summer steelhead that return to the Sandy Hatchery maybe recycled to provide for additional harvest opportunities as described in the Proposed Action (Sections 1.3.3 and 1.3.4). For the purposes of this statement, mortalities will not exceed those identified in Table 2. ODFW will report annually the number of adults handled and any mortalities incidental to the operation of the weirs.

Weir Operation

To collect spring Chinook salmon broodstock and to reduce the number of hatchery spring Chinook salmon that may spawn naturally, ODFW will operate weirs in the Salmon River, Zigzag River, and Bull Run River.

The operation of the weirs is expected to result in take of ESA-listed spring Chinook salmon due to associated factors such as weir rejection, migration delay, and delayed mortality after release due to collection at the weir (this is in addition to the direct mortality from handling at the weirs that is identified in Table 2). It is not possible to accurately quantify this take because meaningful measurements cannot be made of such factors or their effects. NMFS will therefore rely on surrogate take indicators, discussed below, that attempt to measure the effects of weir rejection, migration delay, and mortality due to handling adult spring Chinook salmon at the weirs. These have a rational connection to the amount of take because they reflect operational delay and the effects of weir operation compared to pre-weir conditions.

These surrogate take indicators will act as triggers for NMFS' review and consultation with ODFW which may lead to reinitiation of the ESA consultation or refinement of the Proposed Action. There is a high level of variability in the natural environment in the Sandy River, as seen by the record low rainfall observed in the summer of 2012 (Zweifel 2013) and in record high water event at the end of September in 2013 (Alsbury 2013a; Lackey et al. 2013). 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 as illustrated by the estimated smolt-to-adult survival rates for the winter steelhead program that ranged from a low of 0.45% to a high of 1.88% for broodyears 2000 to 2007 (ODFW 2013g). 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. 2014), time of first spawning, (e.g., for the Zigzag River above Still Creek the range was from August 25 to September 20th (Whitman et al. 2014)) and peak spawning (e.g., in the upper most section of the Salmon River, peak spawning ranged from September 24th to October 15th (Whitman et al. 2014)). Surrogate take indicators attempt to identify changes to the natural populations that are due to the operation of the weirs by comparing things such as redd distribution and pre-spawning mortality before and after the operation of the weirs. Because of the natural variability described above, it is difficult to determine if the changes in these types of comparisons are due to the operation of the weirs or to changes in the natural environment.

Due to this natural variability, for each of the surrogate take indicators below, NMFS will use a three-year moving average beginning in 2014. NMFS will also monitor annual reports (Section 2.10) to determine if the surrogate take indicators have been exceeded in a single year and

whether that exceedance would be such that the three-year moving average could not be achieved.

Surrogate for Weir Rejection

Weir operation may affect spring Chinook salmon spawning distribution due to delay and weir rejection (see Section 2.4.1.2). Weir rejection cannot be reliably observed and quantified, because there is no realistic way to accurately survey weir rejection as it is occurring. Therefore NMFS will rely on a surrogate take indicator measuring the extent to which spawning distribution is changing, likely attributable to the weirs.

Determining changes in spawning distribution is a reasonable surrogate for weir rejection, because weir rejection tends to lead to increased spawning downstream of the weir. Not all change in distribution is attributable to the presence of weirs, but a change beyond a certain level can be reasonably assumed to exceed natural variability, and therefore relate to weirs. Additionally, changes in spawning distribution can be observed and measured in a reasonably reliable manner. NMFS requires ODFW to monitor spawning distribution in the vicinity of each weir. In recent years, redd distribution has been estimated for specific stream sections, and comparing the incidence of spawning in those stream sections can be used to determine if the operation of the weirs is affecting spawning distribution. ODFW has identified three sections of the Salmon River, and three sections of the Zigzag River (Figure 12) where they recorded the number of redds observed for each of those sections during the period from 2002-2007 when no weirs were present, and determinations were made regarding the proportion of spring Chinook salmon redds in each section (Whitman et al. 2014). The Zigzag River and Salmon River within the upper basin encompass the majority of the natural spawning habitat for spring Chinook salmon in the Sandy River Basin. The proposed weir locations are within the lower survey sections of each of these tributaries. Averaging out the distribution of spring Chinook salmon for the period 2002-2007, ODFW determined the following:

- On average, 33.9% of the spring Chinook salmon spawning in the Salmon River spawned in the lower section (and 66.1% spawned in the upper two sections); and
- On average, 25.8% the spring Chinook salmon spawning in the Zigzag River spawned in the lower section (and 74.2% spawned in the upper two sections, including Still Creek).

To apprehend changes to spawning distribution caused by placement of weirs (which began in 2011), the surrogate take indicator examines the changes in redd distribution by comparing the proportion of redds observed in each of the surveys sections with the average proportions that were observed during the 2002-2007 period (see Figure 13 and Figure 14). As discussed above, the expected level of take in the form of changes in spawning distribution caused by the weirs is minimal, and in any case shall not exceed an absolute increase of 10% in spawning of spring Chinook salmon in the lower sections of the Salmon and Zigzag rivers. Therefore, the level of incidental take that is attributed to the Proposed Action would be exceeded when the 3-year average of the proportion of redds in the lower sections exceeds 43.9% of the total number of redds in the Salmon River and 35.8% of the total number of redds in the Zigzag River.

The surrogate serves as a reasonable and reliable measure of incidental take, because if the distribution of redds increases in areas now affected by the weirs compared to the average proportion observed (as a measure of distribution) under natural conditions pre-weir placement, then it is reasonable to conclude that the weirs are causing this change and that spring Chinook salmon are choosing to spawn below the weir in greater-than-expected numbers and are doing so because they are having difficulty passing the weirs. Upon reaching such a threshold, ODFW and NMFS would conduct a more intensive review, the goal of which would be to determine if the shift in spawning was due to the operation of the weirs or due to environmental factors (see discussion above). If the change was due to the weirs, ODFW will propose changes to the operation of the weirs to minimize the effects, and NMFS will likely require reinitiation of consultation (Section 2.10). ODFW will continue to monitor redd distribution within the Salmon River and Zigzag River annually. As described above, a 3-year moving average, beginning with return year 2014, will be used for this surrogate take indicator because this will allow for naturally occurring variations in the proportion of redds in the lower survey sections (Whitman et al. 2014). For example, the proportion of redds in the lower Salmon River has varied annually from 27% to 50% and this is the reason for using a 3-year moving average as opposed to single year.

Surrogate for Migration Delay

Take in the form of migration delay due to weir operations cannot be easily measured. Data are not available on spring Chinook salmon migration patterns in the Zigzag River and Salmon River prior to the existence of the weirs. Without knowing what normal migration patterns were in the past, comparisons to migration timing changes due to the presence of weirs cannot be reliably established.

NMFS therefore proposes to rely on a surrogate measure of migration delay, consisting of changes in the date of peak spawning. This is a reasonable surrogate for a delay in migration, which would likely be reflected in a later date of peak spawning.[24] ODFW, using data collected during spawning ground surveys, has estimated the date of first spawning (Figure 15) and the peak spawning date (Figure 16) for the Salmon River and for the Zigzag River (Schroeder et al. 2013; Whitman et al. 2014) for most years since 2002.

To ascertain the changes in peak spawning that are caused by operation of the weirs, the surrogate take indicator examines the changes in the peak spawning date by comparing the annual peak spawning date with the range of peak spawning dates observed prior to the operation of the weirs (2002-2010) (Figure 16). Take associated with migration delay would be indicated by three consecutive years where the peak spawning date is outside the range observed before weir operation. Even if peak spawning remains within the range, NMFS will monitor the trend in the peak spawning date to determine if the operation of the weir is shifting the date away from the pre-weir mean, and may require changes or reinitiate consultation as a result.

[24] The date of first spawning may be affected by the spawning ground survey schedule and thus NMFS will not use this as a surrogate take indicator. Spawning ground surveys are not conducted daily and thus the scheduling of the earlier surveys may affect the detection of the initiation of spawning. NMFS will monitor the date of first spawning to determine if there is a trend away from the mean observed pre-weir operation.

The surrogate serves as a reasonable and reliable measure of incidental take, because if the peak spawning date is continuously outside the range observed under natural conditions before the weirs were operated, then it is reasonable to conclude that the weirs are causing this change and that spring Chinook salmon have altered their date of peak spawning because they are having difficulty passing the weirs. Exceedance of the surrogate would trigger a more intensive review by ODFW and NMFS to determine if the shift in the peak spawning date was due to the operation of the weirs or due to environmental factors (Section 2.4.2.2). If the change was due to the weirs, ODFW will propose changes to the operation of the weirs to minimize the effects and NMFS will likely require reinitiation of consultation (Section 2.10).

NMFS would prefer to develop a more robust surrogate for migration delay that could be based on ODFW snorkel surveys below the weirs. Although not part of the surrogate, ODFW will monitor adults spring Chinook salmon below the weirs. ODFW collected one year of data in 2013 looking at the relationship between snorkel counts below the weirs and passage through the trap. NMFS does not believe that there is enough data available now to be able to develop a surrogate take indicator for migration delay using the snorkel surveys. NMFS will work with ODFW over the next two years (2014 and 2015) to monitor the relationship between the number of spring Chinook salmon entering and passing through the trap and the abundance of spring Chinook salmon observed below the weir.

The sections of river immediately below the weirs will be snorkel surveyed at least once per week to determine abundance and distribution of fish below the weirs. ODFW proposes to increase the frequency of the snorkel surveys beginning the second week of September because this has been the period of greatest upstream movement. ODFW will also estimate the proportion of natural-origin spring Chinook salmon present below the weirs so that migration timing between hatchery and natural-origin adults can be compared. NMFS' primary concern is passage delay for natural-origin spring Chinook salmon. An increase in the abundance of fish observed below the weir without a corresponding increase in the number of spring Chinook salmon processed through the trap would indicate delayed adult migration, but as described above (Section 2.4.2.2), spring Chinook salmon movement into the tributaries below the weir may be due to other environmental factors independent of weir operation. Data collected from the snorkel surveys and weir passage will be evaluated to determine if changes between the abundance of spring Chinook salmon in the stream reaches below the weir and the number of natural-origin spring Chinook salmon entering the trap prior to the next snorkel survey can be used as an indicator of migration delay. If and when appropriate, NMFS will amend this statement.

Surrogate for Delayed Trapping and Handling Mortality

As discussed above, trapping and handling salmonids at weirs can result in impacts that are not manifested until after release. An indication of this delayed mortality is the level of pre-spawning mortality observed in salmonids following release. Generally, pre-spawning mortality can be reliably detected and quantified during spawning ground surveys, where salmon and steelhead carcasses can be used to determine if spawning had occurred prior to death by examining carcasses for retained eggs. However, pre-spawning mortality can occur naturally as well, not solely as a result of trapping and handling.

It is not possible to directly accurately observe and quantify pre-spawning mortality that is attributed to the Proposed Action, because where carcasses indicate pre-spawning mortality, there is no evidence as to the precise cause. This is in addition to direct handling mortality identified in Table 2. Therefore, NMFS will rely on a surrogate take indicator measuring the change in pre-spawning mortality from past years before weirs were installed in the Sandy Basin. Specifically, the surrogate take indicator for delayed mortality after release is an absolute increase of greater than 5% in pre-spawning mortality from what was measured during previous spawning ground surveys prior to the installation and operation of the weirs in 2011.

During the period from 2003 to 2007 spring Chinook salmon were trapped and handled at Marmot Dam which probably contributed to increased pre-spawning mortality. 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 (pre-spawning mortality) averaged 8.2% in the Salmon River, and 2.9% in the Zigzag River (Whitman et al. 2014). The three-year average take associated with delayed mortality from handling at the weirs as measured as pre-spawning mortality must not exceed 13% in the Salmon River and 8% in the Zigzag River (an absolute increase of approximately 5% over what was observed in 2008 and 2009). Exceedance of the surrogate in a single year would trigger a more intensive review by ODFW and NMFS to determine if the cause was due to the operation of the weirs or some environmental factor. This surrogate serves as a reasonable and reliable measure of incidental take, because NMFS expects that the weirs have a minimal effect on pre-spawning mortality, and the absolute change of 5% will allow for naturally occurring annual variability in pre-spawning mortality estimates while still providing protection to the ESA-listed spring Chinook salmon. Schroeder et al. (2013) observed that the pre-spawning mortality was variable in the upper Sandy River Basin (range = 0-17%), and the surrogate take limits are well within the range that was observed before weir operations were implemented. ODFW, as part of the spring Chinook salmon spawning ground surveys will annually monitor and report pre-spawning mortality estimates for the Salmon Rivers and Zigzag Rivers.

For pre-spawning mortality in the Bull Run River Basin, there is not a historical baseline and therefore no reliable measure for delayed trapping and handling mortality attributable to the operation of the weirs. Therefore, NMFS will rely instead on the amount of take by handling in the Bull Run River Basin. Up to 80 natural-origin spring Chinook salmon could be handled as a result of weir operations in the Bull Run River Basin. The number of fish handled is a good indicator of pre-spawning mortality because handling and delay can both contribute to pre-spawning mortality. Pre-spawning mortality will be monitored and compared to trends observed for the Upper Sandy River Basin to determine if there are impacts from the operation of the weir. Pre-spawning mortality in the Bull Run River Basin will be included as part of the annual spawning survey report. As more data becomes available, NMFS may amend this section to rely on a pre-spawning mortality take indicator.

(2) Interactions on the Spawning Grounds

pHOS

When hatchery fish are not harvested or do not return to release locations, interactions with listed fish on the spawning grounds can occur, and the result is take of the natural populations by way of hatchery-influenced selection effects. It is not possible to ascertain the exact amount of such take, because it is not possible to meaningfully observe and measure the number of interactions between hatchery and natural-origin fish, nor their precise effects. NMFS will therefore rely on a surrogate for an indication of the level of incidental take by hatchery-influenced selection effects. For all salmonid species, pHOS is the appropriate surrogate measure from this form of incidental take, and will be used as follows:

- For the Sandy River spring Chinook salmon population, a pHOS of <10% for the entire spawning population, using a three-year moving average. This means that starting with the first complete available set of data following issuance of this opinion (likely data for 2014), NMFS will determine annually whether take has been exceeded once three years of data become available, unless NMFS determines after one or two years (of the three-year moving average period) that pHOS is so high that attainment of the <10% average across three years is not a reasonable expectation, in which case NMFS will declare the threshold to have been exceeded at that time.
- For the Sandy River coho salmon population, a pHOS of <5% for the entire spawning population, using a three-year moving average. This means that starting with the first complete available set of data following issuance of this opinion (likely data for 2014-2015 returns), NMFS will determine annually whether take has been exceeded once three years of data become available, unless pHOS after one or two years is so high that attainment of the <5% average across three years is not a reasonable expectation, in which case NMFS will declare the threshold to have been exceeded at that time. Note that the section of Cedar Creek from the mouth to the Sandy Hatchery will not be included in the calculation because live fish counted in this section during surveys may still enter the hatchery prior to spawning. However, coho salmon released into Cedar Creek above the hatchery will be included in the calculation of pHOS.
- For the Sandy River winter steelhead population, a pHOS of <10% for the entire spawning population, using a three-year moving average. This means that starting with the first complete available set of data following issuance of this opinion (presumably data for 2015), NMFS will determine annually whether take has been exceeded once three years of data become available, unless pHOS after one or two years is so high that attainment of the <10% average across three years is not a reasonable expectation, in which case NMFS will declare the threshold to have been exceeded at that time. Note that the section of Cedar Creek from the mouth to the Sandy Hatchery will not be included in the calculation because live fish counted in this section during surveys may still enter the hatchery prior to spawning. However, winter steelhead released into Cedar Creek above the hatchery will be included in the calculation of pHOS.
- Sandy River hatchery summer steelhead must be <5% of the naturally spawning Sandy River winter steelhead population, using a three-year moving average. This means that starting with the first complete available set of data following issuance of this opinion

(presumably data for 2015), NMFS will annually determine whether take has been exceeded once three years of data become available, unless pHOS after one or two years is so high that attainment of the <5% average across three years is not a reasonable expectation, in which case NMFS will declare the threshold to have been exceeded at that time.

Using pHOS serves as a reasonable and reliable measure of incidental take because actual genetic introgression due to hatchery-influenced selection is difficult to measure consistently and effectively, due to cost and time involved, and studies have shown that there is a close correlation between pHOS and introgression. As noted above, pHOS does not necessarily result in introgression, and the actual introgression occurring may be much lower. However, genetic introgression cannot take place without hatchery-origin spawners present on the spawning grounds. Therefore, pHOS is a thorough, if conservative, indicator of the actual effects. If any of the thresholds identified above is exceeded, this will trigger and intensive evaluation by ODFW and NMFS to determine the effective pHOS. As described above, the proportion of hatchery fish spawning naturally does not directly measure genetic introgression due to hatchery-influence selection 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 (see discussion in Section 2.4.1.2). If the effective pHOS exceeds thresholds, ODFW will propose changes to the hatchery program to minimize the effects, and NMFS will likely require reinitiation of consultation (Section 2.10).

ODFW will monitor the presence of hatchery fish on the spawning grounds to verify compliance with these standards. A 3-year moving average will provided for the natural variability in natural and hatchery salmon and steelhead survival as well as environmental factors that can affect monitoring effectiveness.

ODFW is authorized to return stray hatchery-origin fish to their hatchery of origin or, alternatively, use the fish for human consumption, stream fertilization, or to support tribal or recreational harvest in areas not accessible to anadromous salmonids.

(3) Interactions in juvenile rearing areas

Incidental take of ESA-listed salmon and steelhead is expected to occur in the form of interactions between juvenile hatchery and natural-origin fish in juvenile rearing areas. This form of take concerns interactions (such as predation or competition for food) between juvenile salmon and steelhead and hatchery smolts emigrating from the hatchery and acclimation pond. It is not possible to quantify the take associated with interactions in rearing areas, because it is not possible to meaningfully measure the number of interactions nor their precise effects. NMFS will therefore rely on a surrogate take indicator that relates to the proportion of hatchery fish in the rearing areas after release from the hatchery and acclimation pond. Specifically, the extent of take from interactions between hatchery and natural-origin juvenile salmonids in rearing areas in the lower Sandy River is as follows: the proportion of juvenile hatchery salmonids in rearing areas in the lower Sandy River shall not exceed 10 percent on or after the 21st day following any hatchery release. As described in the annual monitoring plan, ODFW will conduct a number of surveys the lower Sandy River using various methods to determine the abundance of hatchery juvenile salmon and steelhead 21 days after release. To further evaluate effects on natural-origin

juvenile salmonids, ODFW will retain all hatchery steelhead juveniles collected, up to 50, and evaluate the stomach contents to determine if predation of juvenile salmonids is occurring.

This surrogate serves as a reasonable and reliable measure of incidental take, because interactions leading to take can only occur when the hatchery juveniles co-occur with natural origin juveniles and the greater percentage of hatchery salmonids in the rearing areas, the greater the chance of take associated with interactions. To verify that the hatchery juveniles are migrating out of the Sandy River Basin, ODFW shall submit to NMFS an annual monitoring plan for NMFS concurrence by March 1of each year.

(4) Construction, operation, and maintenance of hatchery facilities (e.g., water intake structures)

The operation of the hatchery facilities is also expected to cause incidental take of ESA-listed salmon and steelhead primarily through water withdrawals, where harm can occur when stream flows are reduced by water withdrawals, reducing the quality and quantity of rearing habitat, and inhibiting migration. The take of ESA-listed salmon and steelhead that may occur from the water withdrawals cannot be directly measured because the take occurs when a reduction in total flow through a section of stream/river reduces the amount of habitat in that section but only at levels that do not prevent the use of the remaining habitat or prevents migration. Moreover, a number of factors will be affecting these salmon and steelhead and it is not possible to make a clear causal link between a reduction in water quantity and adverse effects. NMFS will therefore rely on a surrogate take indicator that relates to the minimum flow requirements in stream sections between the facility intake and facility outfall. Specifically, the surrogate take indicator is water withdrawals that reduce flow to below minimum flow levels when the hatchery facility is being operated, or exceed the maximum proportion of flow diversion for the source stream during the period that the program fish are present (details below).

These surrogates serve as reasonable and reliable measures of incidental take, because the water withdrawals directly cause the take at issue, and are measurable because the hatchery facilities will record and report its water usage as part of its permit. Water withdrawals at the Bull Run acclimation will not impact ESA-listed salmon and steelhead because the intake and outfall are located in the same pool, and the screen meets NMFS criteria. Water withdrawals for the Sandy Hatchery will affect the section of Cedar Creek between the intake and outfall. The anticipated level of incidental take will be exceeded if the minimum flow of 2.3 cfs during the summer months (June 1 to September 30), and a minimum flow of 5.0 cfs during the normal adult migration period are not maintained in that section of Cedar Creek between the intake and the hatchery outfall.

Similarly, water withdrawals for the Clackamas Hatchery will affect a ¼ mile section of the Clackamas River from the intake to the outfall and thus the anticipated level of incidental take will be exceeded if the water diversion is more than 2% of the flow from June through September during the period that Sandy River spring Chinook salmon broodstock are being held and spawned at the Clackamas Hatchery.

Water withdrawals at the Cascade Hatchery during the summer time period will reduce flows to minimal levels in the section of Eagle Creek from the intake to the hatchery outfall. However,

incidental take as a result of operating water intake structures on behalf of the proposed action is not anticipated in this location because the habitat in this section is of very poor quality due to high gradient, and limited instream large woody debris due to high velocities and frequent flooding, and inundation by the Bonneville Dam pool that increases water temperatures, and as a result it does not support juvenile rearing.

(5) Research, Monitoring, and Evaluation (ME&R)

ME&R activities will handle juvenile coho salmon and steelhead during the operation of the screw trap on Cedar Creek. These activities support recolonization of Cedar Creek by coho salmon and winter steelhead. ODFW is expected to handle up to 5,000 coho salmon and 3,500 winter steelhead smolts annually, with a mortality level not to exceed one percent of the juveniles collected (Table 2). Consequently, these numbers represent the expected take associated with ME&R.

2.8.2. Effect of the Take

In Section 2.7, NMFS concluded that the level of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence of the LCR Chinook and Coho Salmon ESUs, and the LCR Steelhead DPS, or adversely modify designated critical habitat for LCR Chinook salmon, and LCR steelhead.

2.8.3. Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). "Terms and conditions" implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in Section 7(a)(2) to apply.

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take:

1. ODFW must implement the hatchery programs and operate the hatchery facilities as described in the Proposed Action, including ME&R activities, (Section 1.3) and in the supplemented HGMPs.
2. Ensure that interactions on the spawning grounds with fish produced by the Sandy Hatchery, hatchery-origin spring Chinook and coho salmon and hatchery-origin winter and summer steelhead, are kept to the lowest feasible levels.
3. Ensure that interactions in the Sandy River with juvenile hatchery fish produced by the Sandy Hatchery, hatchery-origin spring Chinook and coho salmon and hatchery-origin winter and summer steelhead, are kept to the lowest feasible levels.
4. Ensure that take resulting from the operation of weirs in the Sandy Basin is minimized.
5. Receives annual reports on the effects of the hatchery operations on ESA-listed species that allow for the evaluation of the continued efficacy of the programs.

2.8.4. Terms and Conditions

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

1a. ODFW implement the hatchery programs as described in the Proposed Action (Section 1.3) and in the submitted HGMPs. NMFS' SFD must be notified, in advance, of any change in hatchery program operation and implementation that potentially would result in increased take of ESA-listed species.

1b. ODFW, in effectuating the take authorized by this ITS, are considered to have accepted the terms and conditions set forth herein and must be prepared to comply with the provisions of this incidental take statement, the applicable regulations, and the ESA.

1c. ODFW take ESA-listed species while conducting ME&R only at levels, by the means, in the areas, and for the purposes stated in Section 1.3.5 of this opinion.

2a. NMFS shall include as a implementation requirement in its written approval that ODFW shall conduct surveys, annually, to determine the timing, abundance, and distribution of Sandy Hatchery spring Chinook and coho salmon and Sandy Hatchery winter and summer steelhead that spawn naturally. The operating agency shall submit protocols for annual surveys for NMFS concurrence on or before June 1 of each year. The operating agency shall submit an annual report describing survey and monitoring results on or before January 1 of each year.

2b. ODFW is authorized to return stray hatchery-origin fish to their hatchery of origin or, alternatively, use the fish for human consumption, stream fertilization, or to support tribal or recreational harvest in areas not accessible to anadromous salmonids.

3. ODFW shall submit to NMFS an annual monitoring plan for NMFS concurrence by March 1 of each year.

4a. Report on the fish encountered at each weir including the species, origin (hatchery or natural-origin), life-stage, timing of the encounter, condition, and any mortalities.

4b. Estimate weir rejection and handling mortalities, by species, for each weir in the Sandy Basin.

5a. The SFD must be notified, in advance, of any change in hatchery program operation and implementation that potentially would result in increased take of ESA-listed species.

5b. OFDW shall provide one comprehensive annual report to the SFD that includes the ME&R described in 1, 2, 3a, and 3b. The numbers of fish released, release dates and

locations, and tag/mark information shall be included in the annual report. All reports, as well as all other notifications required in the permit, shall be submitted electronically to the SFD point of contact on this program:

Richard Turner (503-736-4737, rich.turner@noaa.gov)

Written materials may also be submitted to:

NMFS – Sustainable Fisheries Division
Anadromous Production and Inland Fisheries
1201 N.E. Lloyd Boulevard, Suite 1100
Portland, Oregon 97232

2.9. Conservation Recommendations

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

1. The ODFW, in cooperation with the NMFS and other entities, should continue to investigate the level of ecological interactions between hatchery-produced salmon and steelhead and ESA-listed steelhead and spring Chinook salmon within the Sandy River Basin to identify additional methods to minimize these interactions.

2.10. Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In addition, reinitiation is required if implementation of the Proposed Action is continued beyond August 15, 2024.

Among other considerations, NMFS may reinitiate consultation if there is significant new information indicating that impacts on ESA-listed species, beyond those considered in this opinion, are occurring from the operation of the proposed hatchery programs, including the operation of weirs and ME&R in support of the hatchery programs, or if the specific ME&R activities listed in the terms and conditions are not implemented.

2.11. "Not Likely to Adversely Affect" Determinations

2.11.1. Columbia River Chum Salmon

NMFS does not anticipate the proposed action will take Columbia River Chum salmon. The CR chum salmon ESU includes all naturally produced chum salmon in the Columbia River and its tributaries in Washington and Oregon (Figure 18). The CR Chum Salmon ESU also includes three hatchery programs (Chinook River, Grays River, and Washougal River/Duncan Creek). 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). Habitat losses limit chum salmon to Columbia River mainstem and tributary areas below Bonneville Dam. The WLCR TRT identified 16 historical populations in the ESU (Figure 18) (Myers et al. 2003). These areas remain where natural spawning is substantial and persistent including the Grays River, the mainstem Columbia River near Portland, Oregon and the mainstem Columbia River and several tributaries in the vicinity of Bonneville Dam. Hatchery fish have had little influence on the status of this ESU.

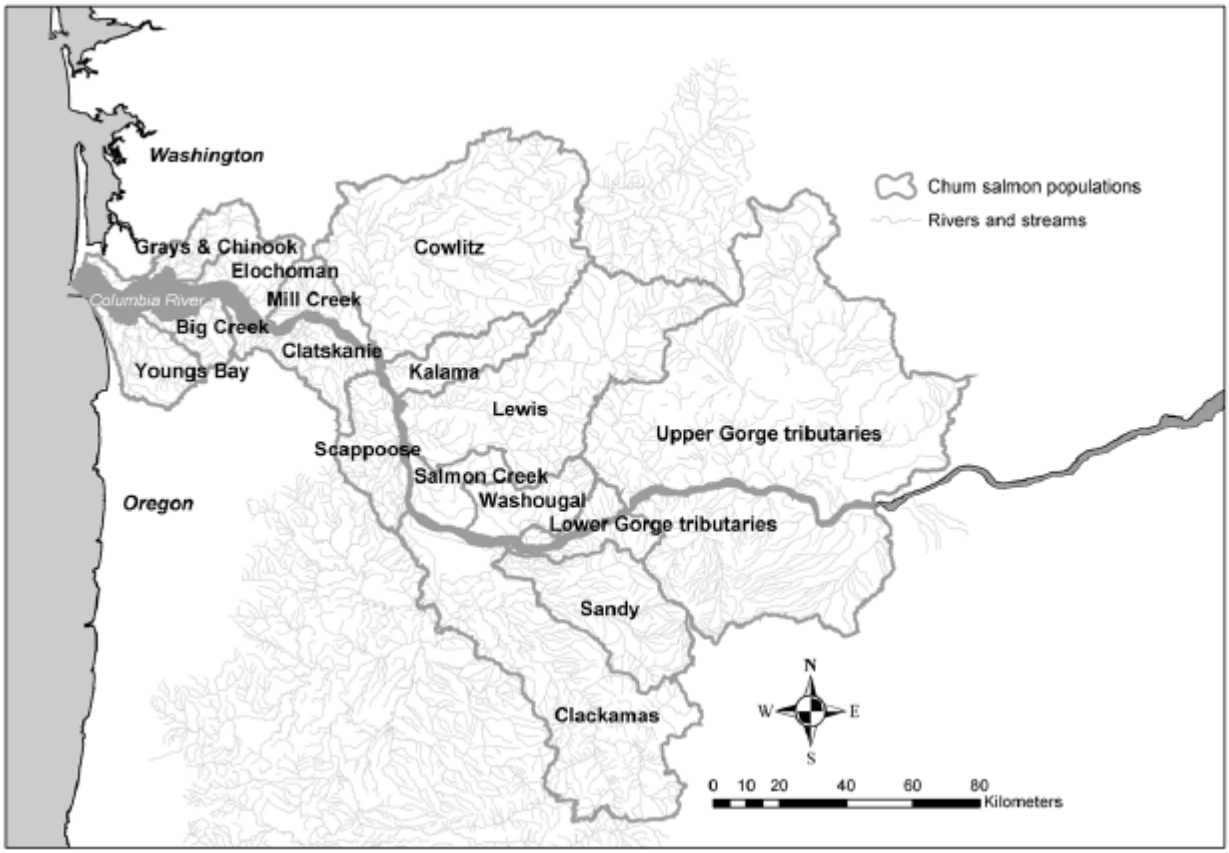

Figure 18. The Columbia River chum salmon ESU (from (Myers et al. 2006)).

Chum salmon are semelparous, spawn primarily in freshwater, and apparently exhibit obligatory anadromy, as there are no recorded landlocked or naturalized freshwater populations (Randall et al. 1987). The species has the widest natural geographic and spawning distribution of any Pacific salmonid. Chum salmon range from Korea and the Japanese island of Honshu, east,

around the rim of the North Pacific Ocean, to Monterey Bay in California. Presently, major spawning populations are found only as far south as Tillamook Bay on the Northern Oregon coast. Chum salmon may historically have been the most abundant of all salmonids: Neave (1961) estimated that prior to the 1940s, chum salmon contributed almost 50 percent of the total biomass of all salmonids in the Pacific Ocean. Chum salmon also grow to be among the largest of Pacific salmon, second only to Chinook salmon in adult size, with individual chum salmon reported up to 108.9 cm in length and 20.8 kg in weight (Fisherman 1928). Average size for the species is around 3.6 to 6.8 kg (Salo 1991).

Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Chum salmon spend two to five years in the northeast Pacific prior to returning to their natal streams (WDFW and PNPTT 2000). Most chum salmon mature as four year old adults (Johnson et al. 1997). Chum salmon usually spawn in the lower reaches of rivers, mainstem and side-channel areas. Some chum salmon spawn up to 100 km from the ocean. Chum salmon, like pink salmon, usually spawn in coastal areas, and juveniles out migrate to seawater almost immediately after emerging from the gravel (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of coho salmon and steelhead, which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means survival and growth in juvenile chum salmon depends less on freshwater conditions than on favorable estuarine and ocean conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp or confuse predators (Miller and Brannon 1982).

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 Sandy River population is considered to be 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 2005b; McElhany et al. 2007). Critical habitat was designated for the Columbia River Chum Salmon ESU and did not include the Sandy River Basin (70 FR 52630, September 2, 2005).

NMFS analyzes seven factors to determine the effects of a hatchery program on ESA-listed species and on designated critical habitat (Section 2.4.2). If chum salmon were present in the Sandy River, take may occur as a result of the Proposed Action from interactions with juvenile hatchery fish. The amount and effect of the take on the ESA-listed chum salmon is expected to be negligible because ODFW will 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. ODFW will verify with monitoring the presence of hatchery juveniles in the lower Sandy River as part of the juvenile outmigration monitoring and results will be reported annually (see Section 2.10).

The LCR salmon and steelhead Recovery Plan (ODFW 2010) did not identify hatchery actions as a factor limiting chum salmon survival and recovery. This analysis has considered recovery planning documents and the potential effects of the proposed action on the Columbia River Chum Salmon ESU, combined with other ongoing activities, inside the Action Area, and determined that the proposed action will not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the ESU.

Considering all potential interactions between chum salmon and the proposed hatchery operations in the Sandy River, effects of the proposed action are not reasonably certain to occur and are therefore discountable, because of the chum salmon are currently extirpated in the Sandy River. Therefore, the proposed action is not likely to adversely affect ESA-listed Columbia River Chum salmon.

2.11.2. Pacific Eulachon

NMFS does not anticipate that the proposed action will take Pacific Eulachon. On March 18, 2010, NMFS listed the southern DPS of Pacific eulachon (Thaleichthys pacificus) as a threatened species (75 FR 13012). 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 eulachon DPS. Take prohibitions via Section 4(d) of the ESA have not been promulgated.

Critical habitat was designated for the southern DPS (76 FR 65324, October 20, 2011); 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.

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 U.S., most eulachon production originates from the Columbia River. Within the Basin, the biggest and most consistent producers of eulachon are the mainstem Columbia and the Cowlitz River. Spawning also occurs in the Grays, Elochoman, Kalama, Lewis, and Sandy Rivers. Eulachon returns to other areas are sporadic, 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 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, and attach to a variety of substrate types, from sand to pea-sized gravel. Newly hatched young, are 4-7 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 three to five years at sea, they return as adults to spawn. Adult eulachon weigh

an average of 0.1 pounds each and are 15 to 20 cm long with a maximum recorded length of 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).

There are few direct estimates of eulachon abundance anywhere in the southern DPS, including in the Sandy River. Eulachon abundance appears to be at or near historically low levels throughout all or a significant portion of the range for the southern DPS. The Columbia River and its tributaries support the largest known eulachon abundance. Although direct estimates of adult spawning abundance are unavailable, records of commercial fishery landings are available beginning in 1888 and continuing almost uninterrupted until recent times (Gustafson et al. 2010). Commercial landings occasionally exceeded 1,000 metric tons and typically exceeded 500 metric tons. Landings averaged less than five metric tons from 2005 to 2008 (Gustafson et al. 2010). Some of this pattern is due to fishery restrictions, which were put in place in response to the sharp declines in abundance. 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 prompted the States of Oregon and Washington to adopt a Joint State Eulachon Management Plan (WDFW and ODFW 2001) and all eulachon fisheries were closed in 2011.

Climate change impacts on ocean habitat are the most serious threat to the persistence of this eulachon DPS (Gustafson et al. 2010). 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. Hydroelectric dams block access to historical eulachon spawning grounds and affect the quality of spawning substrates through flow management, altered delivery of coarse sediments, and siltation. Dredging activities in the Cowlitz and Columbia Rivers, during the eulachon spawning run, may entrain and kill fish, or otherwise result in decreased spawning success. Eulachon carry high levels of chemical pollutants (EPA 2002) and, although it has not been demonstrated that high contaminant loads in eulachon have increased mortality or reduced reproductive success, such effects have been shown in other fish species (Kime 1995). These factors (and others) have negatively affected the DPS's habitat to the extent that it was necessary to list them under the ESA.

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).

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. 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 very small. 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).

Because eulachon life histories are typically lived out in areas of the Sandy River Basin downstream of the structures associated with the Proposed Action, eulachon habitat and migratory access would not be affected by the presence of those structures which are located upstream of designated critical habitat for the Eulachon DPS.

Considering all potential interactions between eulachon and the proposed hatchery operations in the Sandy River, effects of the proposed action are not reasonably certain to occur and are therefore discountable, because of the slight temporal overlap between the species and the brief time that rapidly outmigrating salmon and steelhead smolts would co-occur with eulachon. Therefore, the proposed action is not likely to adversely affect ESA-listed Pacific eulachon of the southern DPS.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

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

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

3.1. Essential Fish Habitat Affected by the Project

The Proposed Action is the implementation of four hatchery programs rearing salmonids in the Sandy River, as described in detail in Section 1.3. The Action Area of the Proposed Action

includes habitat described as EFH for Chinook and coho salmon. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook and coho salmon.

The area affected by the Proposed Action includes the Sandy River Basin.

As described by PFMC (2003b); (PFMC 2003a):

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

The aspects of EFH that might be affected by the Proposed Action include effects of hatchery operations on ecological interactions and genetic effects on natural-origin Chinook salmon and coho salmon in spawning and rearing areas.

3.2. Adverse Effects on Essential Fish Habitat

The Proposed Action generally does not have effects on the major components of EFH. Spawning and rearing locations and adult holding habitat are not expected to be affected by the operation of the program, as no modifications to these areas would occur, however, temporary weirs would be installed that would impede migration. Potential effects on EFH by the proposed action are only likely to occur in areas that spring Chinook and coho salmon spawn naturally and in the migration corridor in the Sandy River.

The temporary weirs will be installed in the Salmon, Zigzag, and Bull Run Rivers to collect and remove hatchery spring Chinook salmon for broodstock and to limit the number of hatchery spring Chinook salmon that could spawn naturally. The effects of the operation on the weirs are described above in Section 2.4.2.2, and include rejection of the weir leading to displaced spawning, migration delay, and increased mortality from handling of fish at the weir. The weirs will be operated to limit these effects, through proper placement, design, and operation of the weirs, using trained personnel to operate the traps at the weirs, checking the traps daily and during high passage periods processing the spring Chinook salmon twice per day, and quickly passing natural-origin spring Chinook salmon without extensive sampling. Coho salmon may only be delayed for short period, during the early part of the adult migration, before the weirs are removed in October.

As described in Section 2.4.2, water withdrawal for hatchery operations can adversely affect salmon by reducing streamflow, impeding migration, or reducing other stream-dwelling organisms that could serve as prey for juvenile salmonids. Water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures. The proposed hatchery program includes designs to minimize each of these effects. Criteria for surface water withdrawal are set to avoid impacts on spring Chinook salmon and coho salmon spatial structure. Further, the minimum flows will be maintained to provide for juvenile and adult migration through the sections of stream from the point of withdrawal to the hatchery outfall and the intake is screened in compliance with NMFS criteria.

The PFMC (2003b) recognized concerns regarding the "genetic and ecological interactions of hatchery and wild fish … [which have] been identified as risk factors for wild populations." The biological opinion describes in considerable detail the impacts hatchery programs might have on natural populations (see Section 2.4.2 above); greater detail on possible effects of hatchery programs can be found in NMFS (2011b). The potential effects, in this case, are adverse effects resulting from increased competition for spawning and rearing sites. A small proportion of hatchery fish returning to the Sandy River is expected to spawn and may compete for space with spring Chinook salmon or coho salmon. Some Sandy River hatchery fish may stray into other rivers but not in numbers that would cause the carrying capacities of natural production areas to be exceeded, or that would result in increased incidence of disease or increases in predators. Predation by adult Sandy River hatchery fish on juvenile natural-origin salmonids would not occur due to timing differences and the fact that adult salmon stop feeding by the time they reach spawning areas, and predation by juvenile offspring of Sandy River hatchery fish on juvenile natural-origin salmonids would not occur for reasons discussed in Section 2.4.2.

3.3. Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the proposed action on EFH for Chinook and coho salmon, NMFS believes that the proposed action, as described in in the HGMPs and the ITS (Section 2.8, above) includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS constitute NMFS recommendations to address potential EFH effects. NMFS shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, are carried out.

To address the potential effects on EFH of hatchery fish on natural fish in natural spawning and rearing areas, the PFMC (2003a) provided an overarching recommendation that hatchery programs:

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

The biological opinion explicitly discusses the potential risks of hatchery fish on native fish populations and their ecosystems, and describes operation and monitoring appropriate to minimize these risks on salmon in the Sandy River Basin. As a result, NMFS has not identified any additional conservation recommendations.

3.4. Statutory Response Requirement

As required by Section 305(b)(4)(B) of the MSA, the NMFS must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations, unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for

avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

NMFS analyzed and determined that the effects of the action on EFH are likely within the range of effects considered in the ESA portion of the opinion, and concluded that the proposed hatchery programs are not likely to adversely affect Pacific Salmon EFH. There will be minimal disturbance of vegetation, and negligible harm to spawning and rearing habitat, migration delay, and to water quantity and water quality. The small effects on EFH might occur as a result of facility operations on habitat or transitory impacts on the migration corridor would be adequately addressed by the steps described in the HGMPs. Because NMFS not identified any EFH conservation recommendations, there is not statutory response requirement.

3.5. Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. NMFS has determined, through this ESA Section 7 consultation, that the operation of the Sandy Hatchery programs as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an ITS. The intended user is NMFS and ODFW. The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of salmonids to the Columbia and Sandy Rivers, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of ESA-listed salmon and steelhead in the Sandy River Basin. This information will improve scientific understanding of hatchery salmon and steelhead effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations.

4.2. Integrity

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

4.3. Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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