Rob Jones  
NMFS Recovery Division  
National Marine Fisheries Service  
1201 NE Lloyd Blvd., Suite 1100  
Portland, OR 97232  

June 12, 2013

Regard: Wells Hatchery Summer Chinook HGMP

Dear Rob:

Public Utility District No. 1 of Douglas County (Douglas PUD) and the Washington State Department of Fish and Wildlife (WDFW) are pleased to submit to the National Marine Fisheries Service (NMFS) the attached final Hatchery and Genetic Management Plan (HGMP) for the Wells Hatchery Summer Chinook Program. Douglas PUD is the owner and funding entity of the program. The WDFW is the current operator of the hatchery and associated monitoring and evaluation program.

Since October 22, 2003, Douglas PUD and WDFW have been operating the Wells Hatchery summer Chinook program as co-permittees under permit No. 1347. The ten-year term of permit No. 1347 expires on October 22, 2013. In May 2013, Douglas PUD received a formal request from NMFS to submit a new HGMP for the Wells Hatchery summer Chinook program. Since late 2012 Douglas PUD, as the lead entity for this HGMP, has been working closely with the Wells HCP Hatchery Committee (HCP HC) to develop a Wells summer Chinook hatchery program that will adhere to the guidance provided by the Hatchery Scientific Review Group and meet the mitigation obligations for inundation losses at the Wells Hydroelectric Project.

In response to NMFS’s recent request to submit an updated HGMP and pursuant to Section 10(a)(1)(B) of the Endangered Species Act and 50 C.F.R. Parts 222-226, Douglas PUD and WDFW hereby submit this letter and the enclosed HGMP to NMFS as an application for a new or amended Section 10 permit to span a new 10-year period starting in October 2013. It is requested that NMFS issue the permit to Douglas PUD and WDFW as co-permittees to the extent of their respective roles as explained in detail within the HGMP.
The Wells Hatchery Summer Chinook HGMP was developed and approved by members of the Wells HCP HC. Members of the HCP HC include the NMFS, the United States Fish and Wildlife Service, WDFW, the Confederated Tribes of the Colville Reservation, the Confederated Tribes and Bands of the Yakama Nation, and Douglas PUD.

The goal of the program is to mitigate for the loss of summer Chinook salmon adults and fishing opportunity (harvest) that would have been available absent the inundation of the Columbia River upstream of the Wells Project. The Wells Hatchery summer Chinook program is a segregated program: juveniles are released downstream of Wells Dam through the outfall channel and the returning adults are collected via the hatchery outfall channel trap and ladder traps at Wells Dam to minimize the number of adult Wells Hatchery summer Chinook that have an opportunity to interact with naturally produced Chinook upstream of Wells Dam. To facilitate the return of adults to the hatchery outfall, fish are spawned, incubated, reared, acclimated and released from Wells Hatchery directly into the Columbia River downstream of Wells Dam. The current production level for the program is 320,000 yearling summer Chinook and 484,000 subyearling summer Chinook. This segregated hatchery strategy has been successfully implemented for several decades at the Wells Hatchery, resulting in minimal contact between Wells Hatchery Chinook and natural spawning populations of anadromous Chinook and steelhead. Stray rates of Wells Hatchery summer Chinook into tributaries are below the thresholds established by the Hatchery Scientific Review Group (HSRG) and below the levels established by the ESA section 10 permit issued by the NMFS for this program.

Roles and responsibilities for the program are as follows: The HCP HC is responsible for overseeing the implementation of the hatchery program and associated monitoring and evaluation studies. Douglas PUD funds facility improvements, operation of and changes to the artificial production programs, and the monitoring and evaluation program. WDFW, Douglas PUD’s current designated agent, is charged with implementing the monitoring and evaluation studies and operating the hatchery facilities at the direction of Douglas PUD.

If you have any questions regarding the Wells Hatchery Summer Chinook HGMP or the operation of the Wells Hatchery, please feel free to contact Greg Mackey at (509) 881-2489.

Sincerely,

Shane Bickford  
Natural Resources Supervisor  
Douglas PUD

Kelly Cunningham  
Deputy Assistant Director  
Washington Dept. of Fish and Wildlife

Enclosures: (1) Hatchery and Genetic Management Plan (HGMP) – Wells Hatchery Summer Chinook Program.

Copy:  Bob Turner – NMFS  
Mike Schiewe – HCP Hatchery Committee Chairman  
HCP Hatchery Committee Members  
Jeff Korth – WDFW  
Jason Wahls - WDFW
## HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>µg/L</td>
<td>micrograms per liter</td>
</tr>
<tr>
<td>BAMP</td>
<td>Biological Assessment and Management Plan</td>
</tr>
<tr>
<td>BKD</td>
<td>bacterial kidney disease</td>
</tr>
<tr>
<td>BY</td>
<td>brood year</td>
</tr>
<tr>
<td>CCT</td>
<td>Colville Confederated Tribes</td>
</tr>
<tr>
<td>cfs</td>
<td>cubic feet per second</td>
</tr>
<tr>
<td>Chelan PUD</td>
<td>Public Utility District No. 1 of Chelan County</td>
</tr>
<tr>
<td>CV</td>
<td>Coefficient of Variance</td>
</tr>
<tr>
<td>CWT</td>
<td>coded-wire tag</td>
</tr>
<tr>
<td>Douglas PUD</td>
<td>Public Utility District No. 1 of Douglas County</td>
</tr>
<tr>
<td>DPS</td>
<td>Distinct Population Segment</td>
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<tr>
<td>ELISA</td>
<td>enzyme-linked immunosorbent assay</td>
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<tr>
<td>EPA</td>
<td>U.S. Environmental Protection Agency</td>
</tr>
<tr>
<td>ESA</td>
<td>Endangered Species Act</td>
</tr>
<tr>
<td>ESU</td>
<td>Evolutionarily Significant Unit</td>
</tr>
<tr>
<td>f/r</td>
<td>fish per redd</td>
</tr>
<tr>
<td>FCRPS</td>
<td>Federal Columbia River Power System</td>
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<tr>
<td>FDA</td>
<td>U.S. Food and Drug Administration</td>
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<tr>
<td>FH</td>
<td>Fish Hatchery</td>
</tr>
<tr>
<td>FL</td>
<td>Fork Length</td>
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<tr>
<td>fpp</td>
<td>fish per pound</td>
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<td>Grant PUD</td>
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<tr>
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<td>gallons per minute</td>
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<tr>
<td>GPS</td>
<td>global positioning system</td>
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<tr>
<td>HxH</td>
<td>hatchery by hatchery</td>
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<td>HxW</td>
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<tr>
<td>HCP</td>
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<td>HETT</td>
<td>Hatchery Evaluation Technical Team</td>
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<td>HGMP</td>
<td>Hatchery Genetic Management Plan</td>
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<tr>
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<td>hatchery-origin broodstock</td>
</tr>
<tr>
<td>HOR</td>
<td>hatchery-origin recruit</td>
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<td>HOS</td>
<td>hatchery-origin spawner</td>
</tr>
<tr>
<td>HRR</td>
<td>hatchery replacement rate</td>
</tr>
<tr>
<td>HSRG</td>
<td>Hatchery Scientific Review Group</td>
</tr>
<tr>
<td>ICTRT</td>
<td>Interior Columbia Basin Technical Recovery Team</td>
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<tr>
<td>IHNV</td>
<td>Infectious Hematopoietic Necrosis Virus</td>
</tr>
<tr>
<td>IHOT</td>
<td>Integrated Hatchery Operations Team</td>
</tr>
<tr>
<td>INAD</td>
<td>Investigational New Animal Drug</td>
</tr>
<tr>
<td>IPNV</td>
<td>Infectious Pancreatic Necrosis Virus</td>
</tr>
<tr>
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<td>Integrated Status and Effectiveness Monitoring Project</td>
</tr>
<tr>
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<td>Incidental Take Statement</td>
</tr>
<tr>
<td>JFP</td>
<td>Joint Fisheries Parties</td>
</tr>
<tr>
<td>M&amp;E</td>
<td>Monitoring and Evaluation</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>USFWS</td>
<td>U.S. Fish and Wildlife Service</td>
</tr>
<tr>
<td>USGS</td>
<td>U.S. Geological Survey</td>
</tr>
<tr>
<td>VIE</td>
<td>visual implant elastomer</td>
</tr>
<tr>
<td>VSP</td>
<td>Viable Salmonid Populations</td>
</tr>
<tr>
<td>WxW</td>
<td>wild by wild</td>
</tr>
<tr>
<td>WDFW</td>
<td>Washington Department of Fish and Wildlife</td>
</tr>
<tr>
<td>Wells HCP</td>
<td>Wells Hydroelectric Project Anadromous Fish Agreement and Habitat Conservation Plan</td>
</tr>
<tr>
<td>WRIA</td>
<td>Water Resource Inventory Area</td>
</tr>
<tr>
<td>YN</td>
<td>Yakama Nation</td>
</tr>
</tbody>
</table>
SUMMARY

This document is the Hatchery Genetic Management Plan (HGMP) for Wells Hatchery summer Chinook program funded by the Public Utility District No 1. of Douglas County (Douglas PUD), and is submitted as a requirement to support Endangered Species Act (ESA) compliance for the operation of the program. This document includes details about the program facilities and operation, as well as information on the potential effects of the program on ESA-listed fish species and measures to avoid, minimize, or eliminate those various effects. The document is organized as follows:

- Section 1 describes the program, including contact information, justification for the program, and performance standards.
- Section 2 provides information on expected and potential effects on ESA-listed salmonid populations from the program.
- Section 3 relates the program to other management objectives for the species.
- Sections 4 through 10 describe details of fish handling, rearing, collection, and release.
- Section 11 discusses the monitoring and evaluation necessary to maintain the program.
- Section 12 summarizes ongoing or future research related to the program.

The Wells Hatchery summer Chinook program receives long-term ESA coverage under Incidental Take Permits associated with the Wells Hydroelectric Project Anadromous Fish Agreement and Habitat Conservation Plan (Wells HCP) (Wells HCP 2002; Appendix A). The decision-making body for hatchery issues under the Wells HCP is the Wells HCP Hatchery Committee (HCP HC), which provides oversight and recommendations for the program as part of the HCP implementation process. Thus, this HGMP is reflective of HCP HC decisions and resultant actions as deemed appropriate and consistent with the Wells HCP. Decisions made by the Hatchery Committee are dynamic and adaptive; thus future updates to this HGMP may be necessary during the ongoing implementation of the Wells HCP.

The goal of the summer Chinook artificial propagation program at Wells Hatchery is to mitigate for the loss of summer Chinook salmon adults and fishing opportunity (harvest) that would have been available in the region in the absence of the Wells Hydroelectric Project. The goal to mitigate for habitat and harvest losses with a “segregated harvest program” is distinctly different than “integrated conservation programs” designed to rebuild and increase natural production of indigenous stocks. Wells Hatchery summer Chinook are released directly into the Columbia River, rather than into tributaries of the Columbia, to minimize the potential impact on natural populations. Stray rates of Wells summer Chinook into tributaries are within containment metrics established by National Marine Fisheries Service (NMFS) and the HCP HC. The program is monitored under a monitoring and evaluation program to assess program performance and risk containment. The degree of straying and potential impacts of Wells Hatchery summer Chinook contribution on the natural spawning population is controlled through harvest and adult management of returns at Wells Hatchery. Broodstock are collected from existing facilities at the Wells Hatchery volunteer channel and are adequate in most years. Adult holding, spawning, incubation, rearing and release occur at the Wells Hatchery.
The Wells summer Chinook program consists of two fixed hatchery-compensation components for inundation mitigation: 320,000 yearling summer Chinook and 484,000 subyearling summer Chinook. Both components are reared entirely at Wells Hatchery, with broodstock collection through the Wells Hatchery volunteer trap, or Wells Dam if necessary, and adult holding, spawning, incubation, and rearing to release all at Wells Hatchery. Broodstock (up to 602) is primarily hatchery origin returns to Wells Hatchery, with up to 10% natural-origin fish to maintain genetic continuity with natural populations in the region. Grow-out and acclimation occur in large earthen ponds that provide Columbia River surface water for imprinting and natural temperature regimes, and also provide a rearing environment with a degree of natural feed available, low densities, and naturalistic substrate. Fish are released directly into the Columbia River from Wells Hatchery, located immediately downstream of Wells Dam at river kilometer 829. Volitional releases for yearlings occur in April and subyearlings in May. The program provides harvest opportunities for commercial, tribal, and recreational fisheries.

Performance standards, indicators, and monitoring details for the program will follow objectives and goals of the Douglas PUD hatchery Monitoring and Evaluation Plan (M&E Plan; Hillman et al., 2013) developed (and subject to periodic updates) by the HCP HC.

Roles and responsibilities for the program are as follows: The HCP HC is responsible for determining program adjustments, considering the methodology described in the M&E Plan, approving yearly M&E implementation plans for Douglas PUD (Appendix C); and, assisting the Washington Department of Fish and Wildlife (WDFW) in developing annual broodstock collection protocols (Appendix D). Douglas PUD funds the following: implementation of the HCP (operations and maintenance required to implement the HCP), facility construction and improvements, changes to artificial production programs, monitoring and evaluation of programs as identified in the M&E Plan and the yearly M&E implementation plans, permit(s), and implementation of the HCP. Douglas PUD’s designated agent(s) and joint permit holder(s) (currently WDFW) implements the M&E Plan and operates the hatchery facilities at the direction of Douglas PUD and according to the terms of the Wells HCP Section 8 “Hatchery Compensation Plan,” and the ESA Section 10 permit(s) for the hatchery programs, in consultation with the NMFS.

WDFW is responsible for the management of adult summer Chinook returning that are in excess of program needs or are strays from segregated programs into priority habitats. WDFW shall also be responsible for all such adult Wells Hatchery summer Chinook from the point at which adult fish are removed from Douglas PUD’s trapping facilities and placed in holding containers or are captured in a fishery (adult management is not part of this program or explicitly included in this HGMP). The Joint Fisheries Managers will determine the disposition of the adult fish once they are removed from the river for purposes other than broodstock.
1.0 GENERAL PROGRAM DESCRIPTION

1.1 Name of Hatchery or Program

Wells Hatchery Summer Chinook Program

1.2 Species and Population (or Stock) under Propagation, and ESA Status

Upper Columbia River (UCR) Summer Chinook salmon (*Oncorhynchus tshawytscha*); summer-run component upstream of Priest Rapids Dam.

Endangered Species Act (ESA) Status: Not listed and not a candidate for listing. In the 1997 “Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California,” National Marine Fisheries Service (NMFS) indicated that summer/fall Chinook salmon in this Evolutionarily Significant Unit (ESU) were not in danger of extinction, nor were they likely to become so in the foreseeable future (Myers et al. 1998).

1.3 Responsible Organization and Individuals

**Name (and title):** William C. Dobbins, General Manager  
**Agency or Tribe:** Public Utility District No. 1 of Douglas County (Douglas PUD)  
**Address:** 1151 Valley Mall Parkway, East Wenatchee, WA 98802  
**Telephone:** (509) 884-7191  
**Fax:** (509) 884-0553  
**Email:** bdobbins@dc pudd.org

**Name (and title):** Phil Anderson, Director  
**Agency or Tribe:** Washington Department of Fish and Wildlife (WDWF)  
**Address:** (main office) Natural Resources Building, 1111 Washington Street, SE, Olympia, WA 98501-2200; (mailing address) 600 Capitol Way N., Olympia, WA, 98501-1091  
**Telephone:** (360) 902-2720  
**Fax:** (360) 902-2947  
**Email:** Philip.anderson@dfw.wa.gov

Douglas PUD (as the owner of the Wells Hatchery and the funder of hatchery facilities, operation and maintenance [O&M] and hatchery program monitoring and evaluation [M&E]) and WDFW (as Douglas PUD’s current hatchery operator and current implementing contractor for the M&E Plan) are joint permit holders for the Wells Hatchery Summer Chinook Program. Future contractors for Douglas PUD, whether for operating Wells Hatchery or for implementing Douglas PUD’s hatchery M&E program would also jointly hold the permit as an agent of Douglas PUD.

Other agencies, tribes, co-operators, or organizations involved, including contractors, and extent of involvement in the program:
• NMFS: HCP Hatchery Committee (HCP HC) representative; Administration of the ESA
• U.S. Fish and Wildlife Service (USFWS): HCP HC representative; Administration of the ESA
• WDFW: HCP HC representative; current contracted hatchery operator
• Confederated Tribes of the Colville Reservation (CCT): HCP HC representative
• Confederated Tribes and Bands of the Yakama Nation (Yakama Nation): HCP HC representative

The five entities in the bulleted list above comprise the Joint Fisheries Parties (JFP) signatory to the Wells HCP.

1.4 Funding Source, Staffing Level, and Annual Hatchery Program Operational Costs

The funding source is Douglas PUD. The staffing level at Wells Hatchery is currently 6.6 full-time-equivalent staff. For fiscal year 2013/2014 the budgeted operational, maintenance and study related costs for the Wells Program are $1,562,526.

1.5 Location(s) of Hatchery and Associated Facilities

Table 1.1. Hatchery facility locations associated with the Wells Hatchery summer Chinook program (located in Water Resource Inventory Area [WRIA] 47; Wells Hatchery/Columbia River/RKm 829.0/Mid-Upper Columbia).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broodstock collection</td>
<td>Wells Hatchery outfall, Wells Dam</td>
</tr>
<tr>
<td>Adult holding</td>
<td>Wells Hatchery</td>
</tr>
<tr>
<td>Spawning</td>
<td>Wells Hatchery</td>
</tr>
<tr>
<td>Incubation</td>
<td>Wells Hatchery</td>
</tr>
<tr>
<td>Rearing</td>
<td>Wells Hatchery</td>
</tr>
<tr>
<td>Acclimation</td>
<td>Wells Hatchery</td>
</tr>
</tbody>
</table>

1.6 Type of program

This HGMP addresses a Segregated Harvest Program.

1.7 Goal and Purpose of Program

1.7.1 Goal

The goal of the summer Chinook artificial propagation program at Wells Hatchery is to mitigate for the loss of summer Chinook salmon adults and associated fishing opportunity (harvest) that would have been available in the region in the absence of the construction of the Wells Hydroelectric Project (Wells Project).
### 1.7.2 Purpose

The purpose of this hatchery program is to meet the Fixed Hatchery Compensation – Inundation mitigation goals established in the Wells HCP (Wells HCP; 2002) in a manner consistent with the overall HCP objectives of rebuilding natural populations and providing opportunity for harvest. With respect to Douglas PUD, the purpose of this hatchery program is to satisfy the hatchery-compensation terms of the Wells HCP\(^1\), which was executed pursuant to Section 10 of the Endangered Species Act (ESA) as a vehicle to permit Douglas PUD to carry out its functions in a manner consistent with the ESA.

### 1.8 Justification for the Program

Wells Hatchery began operation in 1967 and is located on the Columbia River west bank of the Wells Dam tailrace. This facility was constructed and is funded by Douglas PUD to mitigate for loss of summer Chinook salmon spawning habitat inundated by Wells Dam. Originally built as a spawning channel, it was reprogrammed to serve as an extended rearing facility in 1977. It now produces both subyearling (484,000) and yearling (320,000) summer Chinook salmon.

The Wells Hatchery summer Chinook program specifically addresses the unavoidable losses of summer Chinook associated with the construction of the Wells Project through inundation of habitat in the Columbia River upstream of the Wells Project. The program provides summer Chinook returning adults for harvest to mitigate for lost harvest opportunity due to habitat inundation.

#### 1.8.1 Legal Agreements & Requirements

This HGMP includes actions required of Douglas PUD pursuant to its Wells HCP, as well as other adult management\(^2\) actions (see Section 1.8.6.2) that are beyond HCP obligations, but represent important fishery management activities that may be implemented by WDFW and others of the JFP. This section is intended to provide background and context to aid in the interpretation and application of the terms and obligations of this HGMP. Specifically, this section (1) identifies and describes the purposes and objectives of the Wells HCP relevant to this HGMP, (2) outlines certain responsibilities and obligations of Douglas PUD based on the commitments and assurances provided in the Wells HCP; and (3) describes certain obligations and responsibilities under the terms of this HGMP.

\(^1\) Douglas PUD’s ESA authorizations consist of two regulatory approval tiers: (1) the general ESA approval of all District operations, which consists of the Section 10 incidental take permits (“ITPs”) issued for the District’s HCP, and (2) the specific approvals (Section 10(a)(1)(A) permits) issued for each of the District’s hatchery programs (such as Permit No. 1347). An overarching adaptive-management framework is relevant to both tiers of Douglas PUD’s ESA approval. Under this adaptive-management framework, the HCP Hatchery Committees are required to develop M&E plans and to make relevant management decisions on an ongoing basis (these functions are described in more detail in Section 1.8.1 below). The adaptive-management framework is relevant to the HCP/ITPs because the HCP specifically establishes the terms of the HCP Hatchery Committee’s responsibilities. The adaptive-management framework is also relevant to the hatchery permits because, through the HCP, the HCP Hatchery Committee is charged with incorporating adaptive management into the hatchery-related activities authorized by the hatchery permits. This adaptive-management framework allows for flexible management of hatchery operations under the terms of the HCPs and the Section 10 permits.

\(^2\) The term “Adult Management,” as used throughout this document, is defined as the selective removal of excess hatchery-origin summer Chinook by means of harvest, translocation, culling, or other method of physical removal of returning adult fish to manage program effects (e.g., pHOS, control of strays, etc.) and for purposes other than broodstock collection or HCP Hatchery Committee-approved monitoring and evaluation activities.
1.8.1.1 Douglas PUD’s Wells HCP

The Wells HCP has been included in the license for the Wells Project (Federal Energy Regulatory Commission [FERC] No. 2149). The Wells HCP is a long-term adaptive management of Plan Species and their habitat as affected by the Project. Parties to this agreement include the NMFS, USFWS, WDFW, CCT, YN, Douglas PUD and the four Wells Project power purchasers. Section 8 of the Wells HCP details the objectives, responsibilities, and requirements of hatchery programs required as mitigation for the operation of the Wells Project, as follows:

8.1 Hatchery Objectives

8.1.1 The District shall provide hatchery compensation for all of the Permit Species including: a) spring Chinook salmon, b) summer/fall Chinook salmon, c) sockeye salmon d) summer steelhead as further described in Section 8 [of the Wells HCP] (Hatchery Compensation Plan)....

8.4.6 Of the existing production commitment of ...32,000 pounds of yearling summer Chinook at about 10 fish per pound (320,000 fish) and 24,200 pounds of subyearling summer Chinook, at about 20 fish per pound (484,000 fish), is compensation for original inundation and shall not be subject to adjustment...

1.8.1.2 Adaptive Management and Section 10 Permits

As detailed in Footnote 1 above in Section 1.7, Douglas PUD’s hatchery program obligations under the HCP are implemented through an adaptive-management process set forth in the HCP and under the direction of the HCP HC. The adaptive-management processes in the HCP are integral to the summer Chinook program described in this HGMP.

Any updated Section 10 permit and associated environmental reviews should incorporate, rely on, and anticipate compliance with the adaptive-management provisions of the HCP as described above. This practice will minimize the need for future modification of the Section 10 permit for normal, ongoing program-oversight decisions of the HCP HC, recognizing that NMFS will play an integral role in determining any future program modifications as a member of the HCP HC.

Douglas PUD HGMP Actions Implementing the HCP

Within this HGMP, the following are Douglas PUD obligations intended to implement the requirement of the HCP. These obligations include providing Fixed Hatchery Compensation for inundation:

- Provide water sources and implement risk-aversion measures as described or similar to those described in Section 4 “Water Source.”
- Provide facility capacity to rear the fish as described in Section 5 “Facilities.”

---

3 Taken from pages 27 and 33 of the Wells HCP.
- Provide broodstock collection facilities—Wells Hatchery outfall and Wells Dam fishways — and funding for an operator for broodstock collection as described in Section 6 “Broodstock Origin and Identity” and Section 7 “Broodstock Collection.”
- Provide funding for an operator to perform the activities described in Section 8 “Mating,” Section 9 “Incubation and Rearing,” and Section 10 “Release.”
- Provide funding for implementation of the hatchery M&E Plan as approved and modified by the HCP HC.
- Under the terms of this HGMP, Douglas PUD via their hatchery operator and/or M&E contractor (currently WDFW) is also obligated to complete and submit all Section 10 permit reporting associated with Douglas PUD’s hatchery obligations.

WDFW HGMP Actions

WDFW is the funding source for elements of the hatchery program that are not Douglas PUD’s obligations under the HCP or hydroelectric license. In particular, WDFW is responsible for performing the management of adult summer Chinook returning that are in excess of or do not conform to program management criteria. WDFW shall also be responsible for all such adult Wells Hatchery summer Chinook from the point at which adult fish are removed from Douglas PUD’s trapping facilities and placed in holding containers or are captured in a fishery (adult management is not part of this program or explicitly included in this HGMP). The Joint Fisheries Managers will determine the disposition of the adult fish once they are removed from the river for purposes other than broodstock.

1.8.2 Program Description

The Wells Hatchery summer Chinook program is described in the subsequent subsections and includes (1) broodstock collection and program size; (2) spawning, incubation, rearing, and release of juvenile summer Chinook; (3) escapement and management of returning adults; and (4) monitoring and evaluation.

The Wells Hatchery summer Chinook program is a segregated harvest program intended to provide harvest opportunity. The program includes two components: 1) a yearling program that releases 320,000 fish annually, and 2) a subyearling program that releases 484,000 fish annually.

Anticipated returns from the program were estimated based on the maximum, minimum, and mean smolt-to-adult returns (SARs) from the 12 most recent complete brood-year returns (1994-2005). The anticipated returns are as follows:

<table>
<thead>
<tr>
<th>Program Component (numbers of smolts released)</th>
<th>Anticipated Number of Adults Returned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum SAR</td>
</tr>
<tr>
<td>Yearling (320,000)</td>
<td>125</td>
</tr>
<tr>
<td>Subyearling (484,000)</td>
<td>15</td>
</tr>
</tbody>
</table>
1.8.2.1  Broodstock Collection and Program Size

Numeric goals for broodstock collection by both programs were developed based on average fecundity, egg-to-smolt survival, and an assumed equal sex ratio.

The proposed smolt-release numbers (up to 320,000 yearling and 484,000 subyearling summer Chinook) for the Wells Hatchery summer Chinook program requires the collection of up to 602 adults.

Table 1.2. Total broodstock collection necessary to meet production targets for the Wells Hatchery summer Chinook program.

<table>
<thead>
<tr>
<th>Program</th>
<th>Release Location</th>
<th>Smolt Objective</th>
<th>Expected Brood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearling</td>
<td>Columbia River</td>
<td>320,000</td>
<td>230\textsuperscript{a}</td>
</tr>
<tr>
<td>Subyearling</td>
<td>Columbia River</td>
<td>484,000</td>
<td>372\textsuperscript{a}</td>
</tr>
<tr>
<td><strong>Wells Hatchery Total</strong></td>
<td><strong>804,000</strong></td>
<td><strong>602</strong></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a} – Values based on a current, mean fecundity of 4,487, an egg-to-smolt survival of 0.761 (subyearling) and 0.836 (yearling), a 1:1 male:female ratio, and 96.8% pre-spawn adult survival. Broodstock numbers reflect a ~ 99% chance of meeting the program production targets.

The Wells Hatchery summer Chinook program collects hatchery-origin broodstock with up to 10% natural-origin broodstock at the Wells Hatchery volunteer channel. The Wells HCP Hatchery Committee must approve inclusion of natural-origin broodstock in excess of 10% of the total broodstock, and collection of natural-origin broodstock from Wells Dam in addition to those captured in the Wells Hatchery volunteer channel. The proposed program would continue to collect hatchery-origin at the Wells Hatchery volunteer channel, or Wells Dam if necessary.

Douglas PUD or its hatchery operator contractor will annually develop site-based broodstock collection protocols. These objectives and protocols may be adjusted in season to meet changes in the abundance, composition, and location of adult returns, and to minimize impacts on non-target fish.

When in operation, trap facilities will be checked and emptied daily, with fish retained for broodstock for holding and spawning, and all other hatchery-origin fish removed to control proportion hatchery-origin spawners (pHOS), and natural-origin fish released to the Columbia River.

The following procedures will be employed to minimize potential adverse impacts on summer Chinook and other incidental species associated with broodstock collection activities:

- All species will be held for a minimal duration in the traps (less than 24 hours).
- Traps and holding areas will be locked or secured against tampering or vandalism.
- Security personnel on-duty while adults are present.
- All natural-origin summer Chinook in excess of broodstock goals will be released upstream immediately without harm.
- All fish, including summer Chinook will be transferred using water-to-water techniques.
1.8.2.2 Spawning, Incubation, Rearing and Release of Juvenile Summer Chinook

Spawning will occur at the Wells Hatchery. The spawning facilities are integrated into the broodstock-holding facilities, allowing the sorting of broodstock for sexual maturity followed immediately by spawning. Fertilization, incubation, and rearing also occur at the Wells Hatchery.

1.8.2.3 Escapement Goals for Natural Spawning Areas

The Wells Hatchery summer Chinook program is a segregated harvest program, although up to 10% of the broodstock may be composed of natural-origin fish. Adult returns are not intended to spawn naturally; therefore, there is no escapement goal for natural spawning areas. However, the goal for the stray rate of Wells Hatchery summer Chinook to natural spawning areas is to comprise less than 5% of the naturally spawning population.

1.8.2.4 Annual Decision-making Regarding Broodstock Collection and Spawning Escapement

The Wells Hatchery summer Chinook program is intended to provide harvest opportunity while functioning as a segregated program. The HCP HC will periodically evaluate whether or not the implemented management decisions have been effective at attaining the stated objectives.

1.8.2.5 Marking Strategy

All juvenile releases will be marked according to a coordinated marking scheme for summer Chinook releases in the Upper Columbia, to be determined by the HCP HC. Currently, all fish are adipose clipped and coded-wire tagged. See Section 10.7 for additional details.

1.8.2.6 Management of Excess Hatchery Fish

The Wells Hatchery summer Chinook program is a segregated program designed to provide opportunity for harvest. Excess escapement (straying) of hatchery fish in relation to wild spawners and habitat capacity may pose genetic and ecological risks to natural populations. Thus, management of adult returns is necessary to meet program objectives. Wells Hatchery summer Chinook are available for harvest in ocean and Columbia River commercial, tribal, and recreational fisheries. Hatchery-origin escapement from fisheries will be removed when fish return to Wells Hatchery through the volunteer channel or as approved by co-managers.

Hatchery summer Chinook removed at locations and by methods described above will be provided to WDFW, and WDFW will assume responsibility for their disposition. WDFW is responsible for funding adult management activities from the point at which fish are removed from Douglas PUD’s trapping facilities and placed in holding containers, or for a recreational fishery. The Joint Fisheries Managers will determine the disposition of the adult fish once they are removed from the river for purposes other than broodstock.
**Permit Holder:** Although Douglas PUD, as a funder, and WDFW, as a contract operator/implementer, are joint permit holders for the Wells Hatchery summer Chinook program, Douglas PUD is not a fish-management agency with authority over fisheries, or for determining the disposition of fish surplus to program needs, and thus cannot hold a permit for such activities. Therefore, WDFW will obtain and hold the necessary permit(s) for adult management activities beyond the point at which summer Chinook are removed from removed from Douglas PUD’s trapping facilities and placed in holding containers or transport vessels, and will also hold any necessary permits for any fisheries on returning adults from the Wells Hatchery summer Chinook program.

**Agent:** WDFW is designated as the authorized agent under a current contract between Douglas PUD and WDFW until this contract expires and is not renewed or renegotiated.

**Conservation Fishery**

A conservation fishery is not a component of the proposed Wells Hatchery summer Chinook program, and thus is not explicitly included as part of this HGMP. Recreational fisheries on adult returns from the Wells Hatchery summer Chinook program are currently allowed and are managed by WDFW and permitted under Section 10 (a)(1)(B) Permit 1554, seperately from this HGMP.

1.8.2.7 Monitoring and Evaluation

M&E plays an important role in measuring program results and determining potential future modifications (adaptive management). M&E information is collected directly from, or derived from broodstock sampling, coded-wire tagging (CWT), adipose clipping, genetic sampling, and disease sampling. M&E objectives for this program are detailed in Section 11.1; typical specific actions are detailed in HCP HC (2007) and Hillman et al. (2013), and risk-aversion measures are detailed in Section 11.2.

Douglas PUD funds the M&E activities for this program as agreed to by the HCP HC in accordance with the processes outlined in the HCP, and WDFW is Douglas PUD’s current contractor for those activities.

**1.9 List of program “Performance Standards”**

See Tables 1.3 and 1.4 in Section 1.10.
1.10 List of program “Performance Indicators”, designated by "benefits" and "risks"

1.10.1 “Performance Indicators” Addressing Benefits

The performance indicators in Tables 1.3 and 1.4 are from the M&E Plan for Douglas PUD programs developed and approved by the HCP Hatchery Committees, titled Monitoring and Evaluation Plan for PUD Hatchery Programs (Hillman et al., 2013). The performance indicators targets are under development by the HCP Hatchery Committee and will be approved by that committee.

Table 1.3. Performance indicators addressing benefits.

<table>
<thead>
<tr>
<th>Performance Standards</th>
<th>Performance Indicators</th>
<th>Monitoring and Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than target hatchery survival rate.</td>
<td>Ho: HRR ≥ Target Value</td>
<td>Evaluate annually</td>
</tr>
<tr>
<td>2. Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.</td>
<td>Ho: Stray rate_{	ext{Hatchery fish}} &lt; 5% of total brood return</td>
<td>Monitor and evaluate hatchery stray rates and proportional contribution to natural spawning aggregates.</td>
</tr>
<tr>
<td></td>
<td>Ho: Stray hatchery fish &lt; 5% of spawning escapement of other independent populations.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ho: Stray hatchery fish &lt; 10% of spawning escapement of any non-target streams within independent population.</td>
<td></td>
</tr>
<tr>
<td>3. Determine if hatchery fish were released at the programmed size and number.</td>
<td>Ho: Hatchery fish_{	ext{Size}} = +/- 10% of Programmed Size</td>
<td>Monitor fish size and number at release.</td>
</tr>
<tr>
<td></td>
<td>Ho: Hatchery fish_{	ext{Number}} = +/- 10% of Programmed Number</td>
<td></td>
</tr>
<tr>
<td>4. Assess adverse impacts to non-target taxa of concern (NTTOC).</td>
<td>Uses PCR-Risk model and expert panel to address risk containment goals set by the HCP HC.</td>
<td>This is a regional objective, the implementation of which requires collaboration among all parties to the Wells HCP. This collaboration has been initiated, including the complicated process for determining the potential for and magnitude of impacts of target species on NTTOC.</td>
</tr>
</tbody>
</table>

4 Monitoring and Evaluation performance indicator targets will be developed and approved by the HCP Hatchery Committee.
### “Performance Indicators” Addressing Risks

Table 1.4. Performance indicators addressing risks.

<table>
<thead>
<tr>
<th>Performance Standards</th>
<th>Performance Indicators</th>
<th>Monitoring and Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Artificial propagation activities comply with ESA responsibilities to minimize impacts and/or interactions to ESA listed fish</td>
<td>Program complies with Section 10 permit conditions including juveniles released from the hatchery at a time that fosters rapid migration downstream. 100% mass mark and CWT fish to identify them from naturally produced fish.</td>
<td>As identified in the HGMP: Monitor size, number, date of release and mass mark quality. Additional monitoring metrics include, straying, effects on NTTOC, and fish health documentation. Required data are generated through the M&amp;E plan and provided to NOAA Fisheries as required per annual report compliance.</td>
</tr>
<tr>
<td>2. Ensure hatchery operations comply with state and federal water quality and quantity standards through proper environmental monitoring.</td>
<td>All facilities meet WDFW water-right permit compliance and National Pollution Discharge Elimination System (NPDES) requirements (NPDES permit No.WAG-5011).</td>
<td>Flow and discharge reported in monthly NPDES reports. Environmental monitoring of total suspended solids, settleable solids, in-hatchery water temperatures, in-hatchery dissolved oxygen, nitrogen, ammonia, and pH will be conducted and reported as per permit conditions.</td>
</tr>
<tr>
<td>3. Water intake systems minimize impacts to listed wild salmonids and their habitats.</td>
<td>Intake screens – designed and operated to assure approach velocities and operating conditions provide protection to wild salmonid species.</td>
<td>Intake system designed to deliver permitted flows. Operators monitor and report as required</td>
</tr>
<tr>
<td>Hatcheries participating in the programs will maintain all screens associated with water intakes in surface water areas to prevent impingement, injury, or mortality to listed salmonids.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Hatchery operations comply with all ESA permit requirements.</td>
<td>Section 10 annual reports are submitted in compliance with permits.</td>
<td>Section 10 annual reports are submitted in compliance with permits.</td>
</tr>
<tr>
<td>Performance Standards</td>
<td>Performance Indicators</td>
<td>Monitoring and Evaluation</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>5. Artificial production facilities are operated in compliance with all applicable fish health guidelines, facility operation standards and protocols including IHOT, Co-Managers Fish Health Policy and drug usage mandates from the Federal Food and Drug Administration</td>
<td>Hatchery goal is to prevent the introduction, amplification or spread of fish pathogens that might negatively affect the health of both hatchery and naturally reproducing stocks and to produce healthy smolts that will contribute to the goals of this facility.</td>
<td>Pathologists from WDFW’s Fish Health Section monitor program monthly. Exams performed at each life stage may include tests for virus, bacteria, parasites and/or pathological changes, as needed</td>
</tr>
<tr>
<td>6. The risk of catastrophic fish loss due to hatchery facility or operation failure is minimized.</td>
<td>Staffing allows for rapid response for protection of fish from risk sources (water loss, power loss, etc.). Backup generators to provide an alternative source of power to supply water during power outages. Protocols in place to test standby generator and all alarm systems on a routine basis. Alarm systems installed and operating at each rearing vessel to detect loss of or reduced flow and reduced operating head in rearing vessels. Densities at minimum to reduce risk of loss to disease. Sanitation – all equipment is disinfected between uses on different lots of fish including nets, crowders, boots, raingear, etc.</td>
<td>Hatchery engineering design and construction accommodate security measures. Operational funding accommodates security measures. Training in proper fish handling, rearing, and biological sampling for all staff. Staff are trained to respond to alarms and operate all emergency equipment on station. Maintenance is conducted as per manufacturer’s requirements and according to hatchery maintenance schedules.</td>
</tr>
<tr>
<td>7. Broodstock collection and release of juveniles to minimize ecological effects on listed wild fish.</td>
<td>All summer Chinook encountered in hatchery broodstock collection operations will be held for a minimal duration in the traps; generally less than 24 hours and follow permit protocols. Juveniles released are imprinted to Wells Hatchery and released at a size and condition to promote migration and return to the facility. Release date and biological parameters will follow HCP HC decisions and Section 10 conditions.</td>
<td>Fish culture and evaluation staff monitor behavior, coefficient of variation in length, and condition. Fish health specialists will certify all hatchery fish before release. Broodstock collection protocols developed each season and reviewed by the HCP Hatchery committees.</td>
</tr>
</tbody>
</table>
1.11 Expected Size of Program

1.11.1 Proposed Annual Broodstock Collection Level

Broodstock collection will occur at Wells Hatchery and Wells Dam. Annual total collection will be up to 602 adults total for the yearling and subyearling components of the program.
1.11.2 Proposed Annual Fish Release Levels By Life Stage and Location

Table 1.5. Proposed annual fish release levels by life stage and location.

<table>
<thead>
<tr>
<th>Life Stage</th>
<th>Release Location</th>
<th>Annual Release Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearling</td>
<td>Columbia River</td>
<td>320,000</td>
</tr>
<tr>
<td>Subyearling</td>
<td>Columbia River</td>
<td>484,000</td>
</tr>
</tbody>
</table>

The program has generally released slightly more than the target number of yearling summer Chinook, and has released fewer than the target number of subyearlings, although the subyearling releases did not differ significantly from the 484,000 target (Murdoch et al. 2012).

Table 1.6. Aggregate number of summer Chinook smolts released to the Columbia River, brood years 1993-2009 (Murdoch et al. 2012).

<table>
<thead>
<tr>
<th>Brood year</th>
<th>Subyearling program Number</th>
<th>Yearling program Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>331,353</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>388,248</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>365,000</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>290,000</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>356,707</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>381,867</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>457,770</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>312,098</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>185,200</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>306,810</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>313,509</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>333,587</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>311,880</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>310,063</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>446,313</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>333,587</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>311,880</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>310,063</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>336,881</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>446,313</td>
<td></td>
</tr>
</tbody>
</table>

Mean       | 421,598                    | Mean                     | 337,983                  |
SD         | 77,323                     | SD                       | 60,236                   |

Subyearling target reduced to 394,000 in 1998 and 384,000 in 1999.
1.12 Current Program Performance, including Estimated Smolt-to-Adult Survival Rates, Adult Production Levels, and Escapement Levels

1.12.1 In-hatchery Survival Measures

Table 1.7. Developmental stage survivals in the hatchery environment for Wells Hatchery summer Chinook, brood years 2005-2009 (Snow et al. 2012).

<table>
<thead>
<tr>
<th>Brood year</th>
<th>Collection to spawning</th>
<th>Unfertilized egg-eyed</th>
<th>Eyed egg-ponding</th>
<th>30 d after ponding</th>
<th>100 d after ponding</th>
<th>Ponding to release</th>
<th>Unfertilized egg-release</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearling 2005-2009</td>
<td>96.7</td>
<td>97.2</td>
<td>89.2</td>
<td>99.0</td>
<td>99.2</td>
<td>99.0</td>
<td>94.1</td>
</tr>
<tr>
<td>Subyearling 2005-2009</td>
<td>96.7</td>
<td>97.2</td>
<td>91.7</td>
<td>93.9</td>
<td>93.6</td>
<td>88.6</td>
<td>87.8</td>
</tr>
<tr>
<td>Standard</td>
<td>90.0</td>
<td>85.0</td>
<td>92.0</td>
<td>98.0</td>
<td>97.0</td>
<td>93.0</td>
<td>90.0</td>
</tr>
</tbody>
</table>
1.12.2 Hatchery Replacement Rates (HRR) and Smolt-to-Adult Returns (SARs)

Table 1.8. Number of summer Chinook broodstock spawned for the yearling program (including pre-spawn mortalities), smolts released, adult returns, SARs, smolts/adult, and HRR by brood year (1992-2008) for the Columbia River releases from Wells Hatchery.

<table>
<thead>
<tr>
<th>Brood year</th>
<th>Number of broodstock</th>
<th>Smolts released</th>
<th>Adult returns</th>
<th>SAR (%)</th>
<th># Smolts/adult</th>
<th>HRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>205</td>
<td>331,353</td>
<td>836</td>
<td>0.252</td>
<td>396</td>
<td>4.1</td>
</tr>
<tr>
<td>1993</td>
<td>225</td>
<td>388,248</td>
<td>2,011</td>
<td>0.518</td>
<td>193</td>
<td>8.9</td>
</tr>
<tr>
<td>1994</td>
<td>185</td>
<td>365,000</td>
<td>141</td>
<td>0.039</td>
<td>2,589</td>
<td>0.8</td>
</tr>
<tr>
<td>1995</td>
<td>144</td>
<td>290,000</td>
<td>1,144</td>
<td>0.394</td>
<td>253</td>
<td>7.9</td>
</tr>
<tr>
<td>1996</td>
<td>193</td>
<td>356,707</td>
<td>1,652</td>
<td>0.463</td>
<td>216</td>
<td>8.6</td>
</tr>
<tr>
<td>1997</td>
<td>189</td>
<td>381,867</td>
<td>10,941</td>
<td>2.865</td>
<td>35</td>
<td>57.9</td>
</tr>
<tr>
<td>1998</td>
<td>207</td>
<td>457,770</td>
<td>10,550</td>
<td>2.305</td>
<td>43</td>
<td>51</td>
</tr>
<tr>
<td>1999</td>
<td>176</td>
<td>312,098</td>
<td>1,544</td>
<td>0.495</td>
<td>202</td>
<td>8.8</td>
</tr>
<tr>
<td>2000</td>
<td>175</td>
<td>343,423</td>
<td>8,300</td>
<td>2.417</td>
<td>41</td>
<td>47.4</td>
</tr>
<tr>
<td>2001</td>
<td>248</td>
<td>185,200</td>
<td>2,700</td>
<td>1.458</td>
<td>69</td>
<td>10.9</td>
</tr>
<tr>
<td>2002</td>
<td>182</td>
<td>306,810</td>
<td>3,677</td>
<td>1.198</td>
<td>83</td>
<td>20.2</td>
</tr>
<tr>
<td>2003</td>
<td>144</td>
<td>313,509</td>
<td>1,924</td>
<td>0.614</td>
<td>163</td>
<td>13.4</td>
</tr>
<tr>
<td>2004</td>
<td>176</td>
<td>312,980</td>
<td>3,629</td>
<td>1.159</td>
<td>86</td>
<td>20.6</td>
</tr>
<tr>
<td>2005</td>
<td>164</td>
<td>333,587</td>
<td>1,759</td>
<td>0.527</td>
<td>190</td>
<td>10.7</td>
</tr>
<tr>
<td>2006</td>
<td>194</td>
<td>311,880</td>
<td>6,718</td>
<td>2.154</td>
<td>46</td>
<td>34.6</td>
</tr>
<tr>
<td>2007</td>
<td>176</td>
<td>310,063</td>
<td>981</td>
<td>0.316</td>
<td>316</td>
<td>5.6</td>
</tr>
<tr>
<td>2008</td>
<td>191</td>
<td>336,881</td>
<td>2,212</td>
<td>0.657</td>
<td>152</td>
<td>11.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geometric mean</th>
<th>Number of broodstock</th>
<th>Smolts released</th>
<th>Adult returns</th>
<th>SAR (%)</th>
<th># Smolts/adult</th>
<th>HRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992-2005</td>
<td>184</td>
<td>328,341</td>
<td>2,241</td>
<td>0.683</td>
<td>146</td>
<td>12.18</td>
</tr>
</tbody>
</table>

1 Preliminary data. Incomplete brood year returns.

In brood years 2003 through 2007 a study was conducted to test the effect of release date on SARs for the subyearling program. Fish had typically been released in mid-June. The study tested a mid-May release date against the traditional mid-June release date. The findings were positive for a switch to an earlier mid-May release, which resulted in substantially higher smolt-to-adult returns (data provided by C. Snow, WDFW, March 29, 2013; Table 1.9).
Table 1.9. Number of summer Chinook broodstock spawned for the subyearling program (including pre-spawn mortalities), smolts released, adult returns, SARs, smolts/adult, and HRR by brood year (1993-2008) for the Columbia River releases from Wells Hatchery.

<table>
<thead>
<tr>
<th>Brood year</th>
<th>Number of broodstock</th>
<th>Smolts released</th>
<th>Adult returns</th>
<th>SAR (%)</th>
<th># Smolts/adult</th>
<th>HRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>173</td>
<td>187,382</td>
<td>40</td>
<td>--</td>
<td>0.021</td>
<td>4.685</td>
</tr>
<tr>
<td>1994</td>
<td>255</td>
<td>450,935</td>
<td>15</td>
<td>--</td>
<td>0.003</td>
<td>30,062</td>
</tr>
<tr>
<td>1995</td>
<td>221</td>
<td>408,000</td>
<td>128</td>
<td>--</td>
<td>0.031</td>
<td>3,188</td>
</tr>
<tr>
<td>1996</td>
<td>336</td>
<td>473,000</td>
<td>704</td>
<td>--</td>
<td>0.149</td>
<td>672</td>
</tr>
<tr>
<td>1997</td>
<td>274</td>
<td>541,923</td>
<td>240</td>
<td>--</td>
<td>0.044</td>
<td>2,258</td>
</tr>
<tr>
<td>1998</td>
<td>179</td>
<td>370,617</td>
<td>376</td>
<td>--</td>
<td>0.101</td>
<td>986</td>
</tr>
<tr>
<td>1999</td>
<td>212</td>
<td>363,600</td>
<td>524</td>
<td>--</td>
<td>0.144</td>
<td>694</td>
</tr>
<tr>
<td>2000</td>
<td>257</td>
<td>498,500</td>
<td>185</td>
<td>--</td>
<td>0.037</td>
<td>2,695</td>
</tr>
<tr>
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<td>210</td>
<td>376,027</td>
<td>776</td>
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<td>0.206</td>
<td>485</td>
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<tr>
<td>2002</td>
<td>265</td>
<td>473,100</td>
<td>126</td>
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<td>3,755</td>
</tr>
<tr>
<td>2003</td>
<td>224</td>
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<td>0.054</td>
<td>0.018</td>
<td>2,798</td>
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<tr>
<td>2004</td>
<td>293</td>
<td>471,123</td>
<td>714</td>
<td>0.169</td>
<td>0.134</td>
<td>660</td>
</tr>
<tr>
<td>2005</td>
<td>262</td>
<td>430,203</td>
<td>2,360</td>
<td>0.706</td>
<td>0.395</td>
<td>182</td>
</tr>
<tr>
<td>2006¹</td>
<td>311</td>
<td>396,538</td>
<td>537</td>
<td>0.157</td>
<td>0.112</td>
<td>738</td>
</tr>
<tr>
<td>2007¹</td>
<td>256</td>
<td>402,527</td>
<td>1,241</td>
<td>0.573</td>
<td>0.137</td>
<td>324</td>
</tr>
<tr>
<td>2008¹</td>
<td>278</td>
<td>427,131</td>
<td>386</td>
<td>0.090</td>
<td>--</td>
<td>1,107</td>
</tr>
</tbody>
</table>

Geometric mean 1993-2005: 239 409,489 246 0.185 0.054 1667 1.067

¹ Preliminary data. Incomplete brood year returns.

1.13 Date Program Started, or is Expected to Start

The first year of operation of Wells Hatchery was 1967. The proposed program as described in this HGMP would continue with the brood year 2013 cohort, pending approval by NMFS.

1.14 Expected Duration of Program

The program is intended to continue for the 50-year term of the Wells HCP, which was accepted by the FERC in 2004.

1.15 Watersheds Targeted by Program

Columbia River, Chelan Water Resource Inventory Area/Columbia Cascade Province, WRIA 47.
1.16 Indicate Alternative Actions Considered for Attaining Program Goals, and Reasons Why Those Actions are NOT Being Proposed

This hatchery program is adaptively managed by the Wells HCP HC. The Wells HCP HC aims for a program of adequate size and characteristics to meet the management goals of the HCP. During the development and implementation of the HCP, many alternatives were considered for this program. The HCP HC developed the program described in this HGMP to meet the current biological, agency, and HCP goals.

2.0 PROGRAM EFFECTS ON NMFS ESA-LISTED SALMONID POPULATIONS

2.1 List All ESA Permits or Authorizations In Hand for the Hatchery Program

2.1.1 Section 10(a)(1)(B) Permit Type: Incidental take (artificial propagation of unlisted salmon): Permit Number 1347

Artificial production of Upper Columbia River (UCR) summer Chinook. Expires October 22, 2013.

Activities described in the application for this permit have been authorized under terms and conditions of the Biological Opinion on the Section 10 Permit No. 1347 (NMFS 2003a). WDFW submits annual reports as conditioned by Section 10 permit No. 1347 covering the period from January 1 to December 31 each year.

2.1.2 Wells Habitat Conservation Plan

In 2002, the Wells HCP was signed by WDFW, USFWS, NOAA National Marine Fisheries Service, and the CCT, and approved by FERC in June of 2004. The YN signed the HCP in March of 2005. The overriding goal of the HCP is to achieve No Net Impact (NNI) on anadromous salmonids as they pass Wells Dam. One of the main objectives of the hatchery component of NNI is to provide species-specific hatchery programs that may include contributing to the rebuilding and recovery of naturally reproducing populations in their native habitats, while maintaining genetic and ecologic integrity, and supporting harvest.

The Wells HCP is intended to be a comprehensive 50-year adaptive management plan for anadromous salmonids and their habitat as affected by the Wells Project. The Wells HCP was designed to address Douglas PUD’s requirements for relicensing and as such included all of the parties terms, conditions, and recommended measures related to regulatory requirements to conserve, protect and mitigate plan species pursuant to ESA, the Federal Power Act, the Fish and Wildlife Coordination Act, the Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act, the Pacific Northwest Electric Power Planning and Conservation Act and Title 77 RCW of the State of Washington. The HCP also obligates the parties to work together to address water quality issues.
2.1.3 Biological Assessment and Management Plan

The Biological Assessment and Management Plan (BAMP) was developed by parties negotiating the HCPs in the late 1990s to document guidelines and recommendations on methods to determine hatchery production levels and evaluation programs. It is used within the HCP as a guidance document for the hatchery programs, but as a supporting document to the Wells HCP, the BAMP itself does not impose any contractual obligations on the signatories to the Wells HCP.

2.2 Provide Descriptions, Status, and Projected Take Actions and Levels for NMFS ESA-listed Natural Populations in the Target Area

2.2.1 Description of NMFS ESA-listed Salmonid Population(s) Affected by the Program

See Section 2.2.3 for populations that may be incidentally affected.

2.2.2 Identify the NMFS ESA-listed Population(s) that may be Directly Affected by the Program

None.

2.2.3 Identify the NMFS ESA-listed Population(s) that may be Incidentally Affected by the Program

Upper Columbia River ESU Spring Chinook

All spring Chinook in the Upper Columbia ESU were listed as Endangered under the ESA on March 24, 1999. The ESU includes all naturally spawned populations of Chinook salmon in all river reaches accessible to Chinook salmon in Columbia River tributaries upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington, excluding the Okanogan River. Chinook salmon (and their progeny) from the following hatchery stocks are considered part of the listed ESU: Chiwawa River (spring run); Methow River (spring run); Twisp River (spring run); Chewuch River (spring run); White River (spring run); and Nason Creek (spring run).

Upper Columbia River DPS Summer Steelhead Trout (*Oncorhynchus mykiss*)

The UCR steelhead Distinct Population Segment (DPS) was listed as threatened on June 18, 2009 (court decision). The DPS includes all naturally spawned populations of steelhead (and their progeny) in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border.

Bull Trout Upper Columbia River DPS (*Salvelinus confluentus*)

On June 12, 1998 bull trout in the Upper Columbia Distinct Population Segment (DPS) were listed as threatened under the ESA by the USFWS.
Other salmonid species

Sockeye salmon in the region were judged as neither in danger of extinction or likely to become so in the foreseeable future by NMFS in the west coast sockeye salmon species status review (Gustafson et al. 1997).

Provide the most recent 12 year:
- Progeny-to-parent ratios
- Survival data by life stage or other measures of productivity
- Annual spawning abundance estimates or other abundance information
- Annual proportions of hatchery origin and natural origin fish on the spawning grounds
- Indicate sources of these data

2.2.3.1 Upper Columbia River ESU Spring Chinook

Progeny-to-parent ratio

During the period 1992-2005, returns per spawner (NRR) for spring Chinook in the Methow sub-basin ranged from 0.02 to 17.89 (Table 2.1). The 12-year geometric mean of returns per spawner during this period ranged from 0.39 to 0.65.

The natural replacement rate (the sum of the numbers of recruits from successive return years that originated from the same brood year, divided by the number of spawners for that brood year) has varied, but remains low, especially in the Methow River spawning area (Table 2.1). The most recent geometric mean of productivity remains near 0.60 for the Methow Basin, which is the same mean value as at the time of listing for the Chewuch and Twisp spawning areas. The geometric mean NRR of the Methow spawning area is approximately half that amount, and, perhaps coincidentally, has the highest proportion of hatchery-origin spawners of the three spawning areas. The Chiwawa River has exhibited less volatility in NRR, and has similar NRR geometric means (1992-2005) to the Chewuch and Twisp rivers (Tables 2.1 and 2.2).
Table 2.1. The natural replacement rate of spring Chinook from the three primary spawning rivers in the Methow River basin for brood years 1992 through 2005 (data from Chapter 5, Appendix A of Snow et al. 2012).

<table>
<thead>
<tr>
<th>Year</th>
<th>Chewuch</th>
<th>Methow</th>
<th>Twisp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>0.10</td>
<td>0.10</td>
<td>0.30</td>
</tr>
<tr>
<td>1993</td>
<td>0.52</td>
<td>0.16</td>
<td>0.12</td>
</tr>
<tr>
<td>1994</td>
<td>0.30</td>
<td>0.18</td>
<td>0.31</td>
</tr>
<tr>
<td>1995</td>
<td>5.53</td>
<td>2.82</td>
<td>3.23</td>
</tr>
<tr>
<td>1996</td>
<td>12.75</td>
<td>17.89</td>
<td>8.64</td>
</tr>
<tr>
<td>1997</td>
<td>7.47</td>
<td>3.53</td>
<td>10.17</td>
</tr>
<tr>
<td>1998</td>
<td>8.96</td>
<td>2.64</td>
<td>12.56</td>
</tr>
<tr>
<td>1999</td>
<td>0.10</td>
<td>0.06</td>
<td>0.30</td>
</tr>
<tr>
<td>2000</td>
<td>0.85</td>
<td>0.40</td>
<td>1.32</td>
</tr>
<tr>
<td>2001</td>
<td>0.11</td>
<td>0.03</td>
<td>0.15</td>
</tr>
<tr>
<td>2002</td>
<td>0.25</td>
<td>0.12</td>
<td>0.37</td>
</tr>
<tr>
<td>2003</td>
<td>0.10</td>
<td>0.15</td>
<td>0.02</td>
</tr>
<tr>
<td>2004</td>
<td>0.24</td>
<td>0.27</td>
<td>0.20</td>
</tr>
<tr>
<td>2005</td>
<td>0.59</td>
<td>0.34</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Geometric mean

<table>
<thead>
<tr>
<th></th>
<th>Chewuch</th>
<th>Methow</th>
<th>Twisp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.65</td>
<td>0.39</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Table 2.2. The natural replacement rate of Chiwawa River spring Chinook for brood years 1989 through 2005 (data from Chapter 5, Hillman et al. 2012b).

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Harvest Not Included</th>
<th>Harvest Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>0.27</td>
<td>0.40</td>
</tr>
<tr>
<td>1990</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>1991</td>
<td>0.01</td>
<td>0.01</td>
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<tr>
<td>1992</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>1993</td>
<td>0.68</td>
<td>0.69</td>
</tr>
<tr>
<td>1994</td>
<td>0.20</td>
<td>0.21</td>
</tr>
<tr>
<td>1995</td>
<td>2.00</td>
<td>2.09</td>
</tr>
<tr>
<td>1996</td>
<td>4.40</td>
<td>4.81</td>
</tr>
<tr>
<td>1997</td>
<td>3.93</td>
<td>4.36</td>
</tr>
<tr>
<td>1998</td>
<td>3.85</td>
<td>4.10</td>
</tr>
<tr>
<td>1999</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>2000</td>
<td>2.02</td>
<td>2.12</td>
</tr>
<tr>
<td>2001</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>2002</td>
<td>0.35</td>
<td>0.36</td>
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<td>2003</td>
<td>0.44</td>
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<tr>
<td>2004</td>
<td>0.32</td>
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</tr>
<tr>
<td>2005</td>
<td>0.68</td>
<td>0.70</td>
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</tbody>
</table>

Average

<table>
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<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
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<td>1.15</td>
<td>1.24</td>
</tr>
</tbody>
</table>

1992-2005 geometric mean

<table>
<thead>
<tr>
<th></th>
<th>Harvest Not Included</th>
<th>Harvest Included</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.634</td>
<td>0.665</td>
</tr>
</tbody>
</table>
Survival data by life stage or other measures of productivity

Stock-recruit curves were fit to the number of reds (stock) to juvenile emigrants (recruits) for the Twisp and Methow rivers (Figures 2.1 and 2.2). The Methow models had low explanatory value (16-20%), while Twisp models explained 35-38% of the variance (Murdoch et al. 2012). A smooth hockey stick model was fit to Chiwawa spring Chinook parr and smolt data, with R² of 0.780 and 0.634, respectively (Figure 2.3). Density dependence was strongest when spawners exceeded 1,300 (Hillman et al. 2012a).

Figure 2.1. Beverton-Holt and Ricker stock recruitment models for Twisp spring Chinook emigrants (Murdoch et al. 2012).
Figure 2.2. Beverton-Holt and Ricker stock recruitment models for Methow spring Chinook emigrants (Murdoch et al. 2012).

Figure 2.3. Relationship between number of spawners and numbers of parr (1991-2009) and smolt (1991-2008) spring Chinook produced in the Chiwawa Basin. Smooth hockey stick model was fit to the stock-recruitment data (Hillman et al. 2012a).
### Annual Spawning Abundance

Table 2.3. Spawning Escapement of Methow basin spring Chinook between the 2003 and 2011 brood years (data from Chapter 5, Snow et al. 2012).

<table>
<thead>
<tr>
<th>Year</th>
<th>Chewuch</th>
<th>Methow</th>
<th>Twisp</th>
<th>Methow Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>W</td>
<td>Total</td>
<td>H</td>
</tr>
<tr>
<td>2003</td>
<td>465</td>
<td>25</td>
<td>490</td>
<td>597</td>
</tr>
<tr>
<td>2004</td>
<td>289</td>
<td>46</td>
<td>335</td>
<td>622</td>
</tr>
<tr>
<td>2005</td>
<td>289</td>
<td>219</td>
<td>508</td>
<td>526</td>
</tr>
<tr>
<td>2006</td>
<td>378</td>
<td>135</td>
<td>513</td>
<td>942</td>
</tr>
<tr>
<td>2007</td>
<td>203</td>
<td>74</td>
<td>277</td>
<td>545</td>
</tr>
<tr>
<td>2008</td>
<td>166</td>
<td>86</td>
<td>252</td>
<td>412</td>
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<tr>
<td>2009</td>
<td>500</td>
<td>271</td>
<td>771</td>
<td>1,480</td>
</tr>
<tr>
<td>2010</td>
<td>341</td>
<td>155</td>
<td>496</td>
<td>1,331</td>
</tr>
<tr>
<td>2011</td>
<td>499</td>
<td>370</td>
<td>869</td>
<td>1,391</td>
</tr>
</tbody>
</table>

*Geometric mean* 326 114 464 785 150 980 70 71 151 1,207 369 1,630
Table 2.4. Spawning Escapement of Chiwawa River spring Chinook between the 1989 and 2005 brood years (data from Chapter 5, Hillman et al. 2012b).

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Spawning Escapement</th>
<th>Harvest Not Included</th>
<th>Harvest Included</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HOR</td>
<td>NOR</td>
<td>HOR</td>
</tr>
<tr>
<td>1989</td>
<td>713</td>
<td>180</td>
<td>204</td>
</tr>
<tr>
<td>1990</td>
<td>571</td>
<td>1</td>
<td>19</td>
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<tr>
<td>1991</td>
<td>242</td>
<td>33</td>
<td>36</td>
</tr>
<tr>
<td>1992</td>
<td>676</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>1993</td>
<td>233</td>
<td>282</td>
<td>286</td>
</tr>
<tr>
<td>1994</td>
<td>184</td>
<td>21</td>
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<tr>
<td>1995</td>
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<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>1996</td>
<td>58</td>
<td>77</td>
<td>79</td>
</tr>
<tr>
<td>1997</td>
<td>182</td>
<td>2,232</td>
<td>2,609</td>
</tr>
<tr>
<td>1998</td>
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<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>2000</td>
<td>346</td>
<td>354</td>
<td>377</td>
</tr>
<tr>
<td>2001</td>
<td>1,725</td>
<td>1,808</td>
<td>1,845</td>
</tr>
<tr>
<td>2002</td>
<td>707</td>
<td>709</td>
<td>780</td>
</tr>
<tr>
<td>2003</td>
<td>270</td>
<td>695</td>
<td>779</td>
</tr>
<tr>
<td>2004</td>
<td>858</td>
<td>2,511</td>
<td>2,986</td>
</tr>
<tr>
<td>2005</td>
<td>598</td>
<td>1,393</td>
<td>1,522</td>
</tr>
<tr>
<td>Average</td>
<td>446</td>
<td>755</td>
<td>851</td>
</tr>
</tbody>
</table>


NP: No Program

Figure 2.4. Spring and summer Chinook salmon redd counts for the Entiat River, 1994-2011 (Hamstreet 2012).
Annual proportions of hatchery origin and natural origin fish on the spawning grounds

Figures 2.5 and 2.6 show the spring Chinook proportionate natural influence (PNI) in the Methow basin and spatial distribution of hatchery and wild spawners in the Methow River (Murdoch et al. 2012). Table 2.5 presents pHOS for the Methow Basin from 2003-2011 (Snow et al. 2012), Table 2.6 presents pHOS for the Chiwawa River (Hillman et al. 2012b), and Figure 2.7 presents hatchery and wild spring Chinook spawning percentages for the Entiat River (Hamstreet 2012).

![Figure 2.5](image1.png)

**Figure 2.5.** The proportionate natural influence (PNI) of the three spring Chinook supplementation programs in the Methow Basin (Murdoch et al. 2012).
Figure 2.6. Mean carcass composition of spring Chinook in the Methow River, 2006 – 2010 (M15 furthest upstream, M6 furthest downstream) (Murdoch et al. 2012).

Table 2.5. The proportion of hatchery origin spawners in the Methow River basin spring Chinook between 2003 and 2011 (data from Chapter 5, Appendix A from Snow et al. 2012).

<table>
<thead>
<tr>
<th>Year</th>
<th>pHOS</th>
<th>Chewuch</th>
<th>Methow</th>
<th>Twisp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td></td>
<td>0.949</td>
<td>0.987</td>
<td>0.419</td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td>0.863</td>
<td>0.758</td>
<td>0.287</td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td>0.569</td>
<td>0.704</td>
<td>0.281</td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td>0.737</td>
<td>0.88</td>
<td>0.606</td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td>0.733</td>
<td>0.782</td>
<td>0.619</td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td>0.659</td>
<td>0.705</td>
<td>0.759</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td>0.649</td>
<td>0.85</td>
<td>0.752</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td>0.688</td>
<td>0.821</td>
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</tr>
<tr>
<td>2011</td>
<td></td>
<td>0.574</td>
<td>0.763</td>
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</table>

Geometric mean 0.704 0.801 0.462
Table 2.6. The proportion of hatchery origin spawners in the Chiwawa River spring Chinook between 2003 and 2011 (data from Chapter 5, Hillman et al. 2012b).

<table>
<thead>
<tr>
<th>Brood Year</th>
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<th>HOS</th>
<th>pHOS</th>
<th>PNI</th>
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</thead>
<tbody>
<tr>
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<td>713</td>
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<td>0</td>
<td>1</td>
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<tr>
<td>1990</td>
<td>571</td>
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<td>1991</td>
<td>242</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1992</td>
<td>676</td>
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<td>1</td>
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<tr>
<td>1993</td>
<td>231</td>
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<td>0.01</td>
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<tr>
<td>1994</td>
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<td>61</td>
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<td>0.67</td>
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</tr>
<tr>
<td>1996</td>
<td>41</td>
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<td>0.29</td>
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<tr>
<td>1997</td>
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<td>0.3</td>
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<td>1998</td>
<td>59</td>
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<td>0.35</td>
<td>0.44</td>
</tr>
<tr>
<td>1999</td>
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<td>502</td>
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<td>0.28</td>
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<td>582</td>
<td>276</td>
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<td>2005</td>
<td>134</td>
<td>464</td>
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<td>2006</td>
<td>116</td>
<td>413</td>
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<tr>
<td>2007</td>
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<td>1,104</td>
<td>0.85</td>
<td>0.25</td>
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<tr>
<td>2008</td>
<td>205</td>
<td>953</td>
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<td>0.25</td>
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<tr>
<td>2010</td>
<td>418</td>
<td>676</td>
<td>0.62</td>
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<tr>
<td>Average</td>
<td>259</td>
<td>333</td>
<td>0.46</td>
<td>0.49</td>
</tr>
</tbody>
</table>
Smolt emigration timing

Smolt trapping has occurred in the upper Columbia since the mid-1990s as part of the hatchery evaluation program. In general, yearling spring Chinook (smolts) migrate down the rivers between early March and the end of May to early June (Figures 2.8, 2.9 and 2.10). Trap efficiencies and periods when traps are inoperable influence the absolute numbers of fish caught on a given date. Table 2.7 provides emigration timing in the Columbia River (PIT tags of wild spring Chinook migrants detected at the Rocky Reach Juvenile Fish Bypass Detector) for 2010-2012, with fish present generally between early April and late May.
Figure 2.8. Daily capture of wild Chinook salmon smolts from the Methow River trap in 2011 (Figure 3, Chapter 3 from Snow et al. 2012).

Figure 2.9. Total daily captures of yearling spring Chinook salmon at the Entiat River rotary screw trap, 2011 (Desgroseillier et al. 2012).
A substantial parr migration occurs in the spring Chinook populations, and appears in two main phases—throughout the summer and then again in the fall (Figures 2.10, 2.11, and 2.12).

Figure 2.10. Monthly captures of wild subyearling, wild yearling, and hatchery yearling spring Chinook at the Chiwawa Trap, 2011 (Hillman et al. 2012a).
Figure 2.11. Daily capture of subyearling spring and summer Chinook salmon at the Methow River smolt trap in 2011. Periods when the trap was not operated or no genetic analysis was conducted are omitted. (Figure 4, Chapter 3 from Snow et al. 2012).

Figure 2.12. Total daily captures of subyearling spring Chinook salmon at the Entiat River rotary screw trap, 2011 (Desgroseillier et al. 2012).
Table 2.7. Emigration timing and presence in the Columbia River of wild spring Chinook juvenile migrants detected at the Rocky Reach Dam Juvenile Fish Bypass PIT-tag detector: 2010-2012 (Data from Columbia River DART [http://www.cbr.washington.edu/dart] accessed on February 29, 2013).

<table>
<thead>
<tr>
<th>Year</th>
<th>Origin</th>
<th>Basin</th>
<th>Release Site</th>
<th>Unique TagIds</th>
<th>Observation Date Percentiles</th>
<th>Middle Percentile Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10%</td>
<td>50%</td>
</tr>
<tr>
<td>2010</td>
<td>Methow</td>
<td>Methow</td>
<td>METTRP</td>
<td>1</td>
<td></td>
<td>7/25/2010*</td>
</tr>
<tr>
<td>2010</td>
<td>Okanogan</td>
<td>Okanogan</td>
<td>OKANR</td>
<td>1</td>
<td></td>
<td>5/24/2010</td>
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<tr>
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<td></td>
<td></td>
<td></td>
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<td>1,305</td>
<td>April 1</td>
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</table>

*Outlier not included in the max date assessment

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<th>Origin</th>
<th>Basin</th>
<th>Release Site</th>
<th>Unique TagIds</th>
<th>Observation Date Percentiles</th>
<th>Middle Percentile Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>423</td>
<td>April 3</td>
</tr>
</tbody>
</table>

<table>
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<th>Release Site</th>
<th>Unique TagIds</th>
<th>Observation Date Percentiles</th>
<th>Middle Percentile Days</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>10%</td>
<td>50%</td>
</tr>
<tr>
<td>2012</td>
<td>Methow</td>
<td>Methow</td>
<td>CHEWUR</td>
<td>72</td>
<td>4/16/2012</td>
<td>4/20/2012</td>
</tr>
<tr>
<td>2012</td>
<td>Entiat</td>
<td>Entiat</td>
<td>MADRVR</td>
<td>1</td>
<td></td>
<td>4/25/2012</td>
</tr>
<tr>
<td>2012</td>
<td>Methow</td>
<td>Methow</td>
<td>TWISPR</td>
<td>64</td>
<td>4/17/2012</td>
<td>4/26/2012</td>
</tr>
<tr>
<td>2012</td>
<td>Methow</td>
<td>Methow</td>
<td>WOLFC</td>
<td>3</td>
<td>5/7/2012</td>
<td>5/9/2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>489</td>
<td>April 2</td>
</tr>
</tbody>
</table>

*Outlier not included in the max date assessment
2.2.3.2 Upper Columbia River DPS summer steelhead trout

Progeny to parent ratio

The natural replacement rate (the sum of the numbers of recruits from successive return years that originated from the same brood year, divided by the sum by the number of spawners for that brood year) has varied, but remains low, especially in the Methow River spawning area (Table 2.8). During the period 1996-2005, returns per spawner (NRR) for steelhead in the Methow sub-basin ranged from 0.0360 to 0.5636 and has average 0.2573 (Table 2.8).

Table 2.8. Run escapement and NRR of Methow Basin steelhead populations calculated from broodstock sampling at Wells Hatchery with corresponding HRR values from Wells Hatchery returns. Escapement values and recruits produced were derived from radio-telemetry data (English et al. 2001, 2003). (Snow et al. 2012)

<table>
<thead>
<tr>
<th>Parent Brood</th>
<th>Methow Run Escapement</th>
<th>Brood at Age</th>
<th>Adults Produced</th>
<th>NRR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1.1, 1.2, 2.1, 1.3, 3.1, 2.2, 2.3, 3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>2,085</td>
<td>2003, 2004, 2005, 2006</td>
<td>1,011</td>
<td>0.4849</td>
</tr>
</tbody>
</table>

Average: 0.2573
Geometric Mean: 0.2030
Survival data by life stage or other measures of productivity

Figures 2.13 through 2.18 present available information on steelhead population dynamics.

Figure 2.13. Abundance of hatchery and naturally produced steelhead in the Methow River (Murdoch et al. 2012).
Figure 2.14. Steelhead stock-recruit relationship between hatchery and wild spawners, combined, and naturally produced adult returns in the Methow River, 1976-2004 (replacement line dashed green) (Murdoch et al. 2012).

Annual Spawning Abundance

The adult abundance of Methow and Okanogan basins steelhead run and spawning escapement is provided in Table 2.10, and adult abundance expressed in redds for the Entiat River is provided in Table 2.12.
### Table 2.10.  
Summer steelhead run escapement, broodstock collection, fishery-related mortality, and maximum spawning escapement estimates at and above Wells Dam. Methow and Okanogan River escapements are based on radio-telemetry data (English et al. 2001, 2003), which account for 90.4% and 91.6% of the hatchery and wild escapement upstream of Wells Dam, respectively. Total count at Wells Dam includes passage from 15 June (run year) to 14 June (spawn year) for brood years 2003 to present; total Wells Dam count for previous years includes the total reported for the run year (prior to spawn). Ladder counts are based on DCPUD raw data for brood years 2000-2011; data for brood year 1999 was based on data from FPC.org. For brood years 2007-2011, proportion of hatchery and wild fish at Wells Dam was estimated through run-at-large sampling; in previous years, proportions were calculated from broodstock trapping records. Estimated double counts and fallback were based on expanded PIT tag interrogation data. Estimated fishery mortality in the Columbia River, brood year 2004, includes fishery-related mortality in the Wells Dam tailrace; all other fishery mortality in the Columbia River occurred in the section between Wells Dam and Chief Joseph Dam. Estimated fishery mortality for hatchery fish in the Methow Basin includes hatchery fish removed as excess (Appendix A of Chapter 4; Snow et al. 2012).

<table>
<thead>
<tr>
<th>Brood year</th>
<th>Total count at Wells Dam based on trapping data and ladder counts from DCPUD</th>
<th>Wells Hatchery broodstock retained</th>
<th>Estimated double counts at Wells Dam</th>
<th>Estimated fallback below Wells Dam</th>
<th>Estimated fishery mortality</th>
<th>Estimated run escapement (using radio-telemetry data)</th>
<th>Estimated fishery mortality</th>
<th>Local broodstock retained</th>
<th>Estimated maximum spawning escapement (using radio-telemetry data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>2,943 242 383 29 -- -- -- -- -- -- -- -- 1,485 151 829 44 -- -- -- -- -- -- -- -- 1,806 279 1,009 82 -- -- -- -- -- -- -- -- 3,900 373 1,893 110 -- -- -- -- -- -- -- -- 10,363 624 5,789 183 -- -- -- -- -- -- -- --</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>3,448 435 334 41 -- -- -- -- -- -- -- -- 1,806 279 1,009 82 -- -- -- -- -- -- -- -- 3,900 373 1,893 110 -- -- -- -- -- -- -- -- 10,363 624 5,789 183 -- -- -- -- -- -- -- --</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>6,167 553 323 26 -- -- -- -- -- -- -- -- 3,900 373 1,893 100 -- -- -- -- -- -- -- -- 1,806 279 1,009 82 -- -- -- -- -- -- -- -- 3,390 373 1,893 110 -- -- -- -- -- -- -- --</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>18,241 900 374 18 -- -- -- -- -- -- -- -- 1,806 279 1,009 82 -- -- -- -- -- -- -- -- 3,900 373 1,893 110 -- -- -- -- -- -- -- -- 10,363 624 5,789 183 -- -- -- -- -- -- -- --</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>8,962 821 274 27 -- -- -- -- -- -- -- -- 455 9 4,775 556 2,668 163 254 13 120 2 -- -- -- -- -- -- -- -- 4,521 543 2,547 157 -- -- -- -- -- -- -- --</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>2004</td>
<td>9,388 1,161 325 120 -- -- -- -- -- -- -- -- 298 4 5,084 734 2,840 216 336 10 385 1 -- -- -- -- -- -- -- -- 4,748 724 2,444 210 -- -- -- -- -- -- -- --</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2005</td>
<td>9,098 861 346 69 -- -- -- -- -- -- -- -- 426 5 4,829 557 2,698 164 679 9 528 3 -- -- -- -- -- -- -- -- 4,150 548 2,155 158 -- -- -- -- -- -- -- --</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>6,901 765 324 91 -- -- -- -- -- -- -- -- 437 4 3,561 474 1,989 139 683 8 486 5 -- -- -- -- -- -- -- -- 2,878 466 1,493 131 -- -- -- -- -- -- -- --</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2007</td>
<td>6,702 631 345 46 -- -- -- -- -- -- -- -- 523 2 3,384 413 1,890 121 -- -- -- -- -- -- -- -- 4,384 413 1,886 114 -- -- -- -- -- -- -- --</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>7,033 1,283 289 90 -- -- -- -- -- -- -- -- 872 8 3,406 839 1,902 247 470 9 288 7 14 0 5 3 -- -- -- -- -- -- -- -- 2,922 830 1,609 237 -- -- -- -- -- -- -- --</td>
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<td></td>
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<td></td>
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<tr>
<td>2009</td>
<td>9,148 1,236 300 75 148 19 409 54 444 5 4,551 767 2,542 225 636 11 446 5 8 8 5 11 -- -- -- -- -- -- -- -- 3,907 748 2,091 209 -- -- -- -- -- -- -- --</td>
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</tr>
<tr>
<td>2010</td>
<td>24,091 2,120 279 88 583 50 1,207 103 1,068 17 12,153 1,318 6,789 387 4,002 48 3,110 16 12 12 4 13 8,139 1,258 3,675 358 -- -- -- -- -- -- -- --</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>11,728 2,085 272 55 206 40 633 273 1,131 19 5,502 1,202 3,073 353 3,024 53 899 15 31 33 0 16 2,447 1,116 2,174 322 -- -- -- -- -- -- -- --</td>
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</tbody>
</table>

Wells Summer Chinook HGMP  
Wells Project No. 2149
Table 2.11. The total number of steelhead redds by reach on the Entiat River, 2006 to 2011 (Desgroseillier et al., 2012).

<table>
<thead>
<tr>
<th>Year</th>
<th>Reach A</th>
<th>Reach B</th>
<th>Reach C</th>
<th>Reach D</th>
<th>Total</th>
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<tbody>
<tr>
<td>2006</td>
<td>38</td>
<td>26</td>
<td>34</td>
<td>13</td>
<td>111</td>
</tr>
<tr>
<td>2007</td>
<td>40</td>
<td>7</td>
<td>14</td>
<td>3</td>
<td>64</td>
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<tr>
<td>2008</td>
<td>93</td>
<td>84</td>
<td>31</td>
<td>14</td>
<td>222</td>
</tr>
<tr>
<td>2009</td>
<td>128</td>
<td>37</td>
<td>27</td>
<td>8</td>
<td>200</td>
</tr>
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<td>87</td>
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<td>55</td>
<td>73</td>
<td>51</td>
<td>26</td>
<td>205</td>
</tr>
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</table>

Annual proportions of hatchery origin and natural origin fish on the spawning grounds

The proportion of hatchery origin spawners (pHOS) is provided in Tables 2.13 and 2.14 for the Methow and Okanogan, and Wenatchee rivers, respectively.

Table 2.12. Proportion of hatchery origin spawners (pHOS) of Methow and Okanogan steelhead supplementation programs for brood years 2001-2011. (derived from data from Snow et al. 2012).

<table>
<thead>
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<th>Brood Year</th>
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<th>Okanogan Spawners</th>
</tr>
</thead>
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<td></td>
<td>H</td>
<td>W</td>
</tr>
<tr>
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<td>1,485</td>
<td>151</td>
</tr>
<tr>
<td>2000</td>
<td>1,806</td>
<td>279</td>
</tr>
<tr>
<td>2001</td>
<td>3,390</td>
<td>373</td>
</tr>
<tr>
<td>2002</td>
<td>10,363</td>
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<td>4,521</td>
<td>543</td>
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<td>4,748</td>
<td>724</td>
</tr>
<tr>
<td>2005</td>
<td>4,150</td>
<td>548</td>
</tr>
<tr>
<td>2006</td>
<td>2,878</td>
<td>466</td>
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<tr>
<td>2007</td>
<td>3,384</td>
<td>413</td>
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<tr>
<td>2008</td>
<td>2,922</td>
<td>830</td>
</tr>
<tr>
<td>2009</td>
<td>3,907</td>
<td>748</td>
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<tr>
<td>2010</td>
<td>8,139</td>
<td>1,258</td>
</tr>
<tr>
<td>2011</td>
<td>2,447</td>
<td>1,116</td>
</tr>
<tr>
<td>Average</td>
<td>4,165</td>
<td>621</td>
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</table>
Smolt emigration timing

Smolt trapping has occurred in the mid-Columbia region since the mid-1990s as part of the hatchery evaluation program. In general, *O. mykiss* juveniles\(^5\) migrate down the rivers between early March and through June (Figures 2.15, 2.17, 2.18). Fry and parr also continue to move through the system throughout the summer and autumn (Figures 2.16, 2.17, 2.18). High water frequently precludes trapping in May and June; therefore, determining the temporal scope of the smolt migration is difficult. Trap efficiencies and periods when traps are inoperable may influence the absolute numbers of fish caught on a given date. Table 2.13 provides emigration timing in the Columbia River (PIT tags of wild summer steelhead migrants detected at the Rocky Reach Juvenile Bypass Detector) for 2010-2012, with fish present generally from early April through the end of May.

\(^5\) Because it is not possible to determine whether juvenile *O. mykiss* are “trout” or “steelhead”, we refer to them by their scientific nomenclature.
Figure 2.16. Daily capture of wild steelhead fry and parr at the Twisp River smolt trap in 2011 (Figure 9, Chapter 3 from Snow et al. 2012).
Figure 2.17. Monthly captures of wild smolts, wild parr, and hatchery smolt steelhead/rainbow at the Chiwawa Trap, 2011 (Hillman et al. 2012b).

Figure 2.18. Total daily captures of steelhead at the Entiat River rotary screw trap, 2011 (Desgroseillier et al. 2012).
Table 2.13. Emigration timing and presence in the Columbia River of wild summer steelhead juvenile migrant detected at the Rocky Reach Dam Juvenile Bypass PIT tag detector: 2010-2012 (Data from Columbia River DART [http://www.cbr.washington.edu/dart] accessed on February 29, 2013).

<table>
<thead>
<tr>
<th>Year</th>
<th>Origin</th>
<th>Basin</th>
<th>Release Site</th>
<th>Unique TagIds Observed</th>
<th>10%</th>
<th>50%</th>
<th>90%</th>
<th>80%</th>
<th>Middle Percentile Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>1,435</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Methow</td>
<td>GOLD2C</td>
<td>1</td>
<td>4/11/2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>1,050</td>
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<td></td>
<td>20</td>
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</tr>
</tbody>
</table>
The current information on bull trout in the mid-Columbia region was synthesized in the 2012 Biological Opinion for the Wells Hydroelectric Project Proposed License (BiOp) issued by the U. S. Fish and Wildlife Service (Lewis 2012). Excerpts from this BiOp are presented here as the most concise and up-to-date synthesis of knowledge. Data on bull trout populations are scarce compared to the more heavily assessed salmon and steelhead populations. Therefore, many basic pieces of information are either impossible to address at this time, or can be addressed in limited fashion. Nevertheless, there is a substantial body of information from which to gain insight into the status of the populations. Juvenile bull trout are rare in the mainstem Columbia River, with none likely to be exposed to Wells Hatchery operations annually (Lewis 2012). Juveniles are the life stage that may be most susceptible to deleterious interaction with a summer Chinook hatchery program, but there appears to be little opportunity for such interactions to occur. Moderate numbers of adult (76) or sub-adult (31) bull were estimated to be likely to be exposed to Wells Hatchery operations annually (Lewis 2012). More detailed information is presented below.

### Table

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Code</th>
<th>Total</th>
<th>Min</th>
<th>Median</th>
<th>Max</th>
<th>Median</th>
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</thead>
<tbody>
<tr>
<td>2012</td>
<td>Methow</td>
<td>BEAV2C</td>
<td>15</td>
<td>4/16/2012</td>
<td>4/30/2012</td>
<td>5/16/2012</td>
<td>31</td>
</tr>
<tr>
<td>2012</td>
<td>Methow</td>
<td>CHEWUR</td>
<td>76</td>
<td>4/23/2012</td>
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<tr>
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<td>310</td>
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<td>1</td>
</tr>
<tr>
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<td>Entiat</td>
<td>INDI2C</td>
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<td>5/28/2012</td>
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</tr>
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<td>2012</td>
<td>Methow</td>
<td>LIBBYC</td>
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<tr>
<td>2012</td>
<td>Methow</td>
<td>METHR</td>
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<td>4/16/2012</td>
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<td>15</td>
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<tr>
<td>2012</td>
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<td>1</td>
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<tr>
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<td>5/19/2012</td>
<td>5/19/2012</td>
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<td>4/24/2012</td>
<td>4/26/2012</td>
<td>5/7/2012</td>
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</table>

**Total** | **Min** | **Median** | **Max** | **Median** |
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<tbody>
<tr>
<td>686</td>
<td>April 16</td>
<td>April 26</td>
<td>May 28</td>
<td>16</td>
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</tbody>
</table>
Progeny-to-Parent Ratio

There are no progeny-to-parent estimates available for Methow or Entiat river bull trout.

Survival Data by Life Stage or Other Measures of Productivity

There are no life-stage specific or other estimates of productivity available other than descriptions of population trends based on redd surveys in the Methow, Entiat, and Wenatchee river systems. The following information was excerpted from the BiOp:

In the Methow Core Area, populations persist at low numbers, in fragmented, local populations. Since 2000, redd counts have varied from 117 to 174, averaging 152. This is slightly higher than the 127 redds at the time of listing. The overall trend for the Methow Core Area is slightly increasing, however, redd surveys are conducted differently every year and there is high variability. (Lewis 2012; page 112).

Currently two local populations of bull trout are found in the Entiat Core Area, one in the upper mainstem Entiat River, and one in the Mad River. Since 2000 the number of redds in the Entiat River has fluctuated between 1 and 50 with great inter-annual variation. Redd counts in the Mad River have varied from 7 to 52, and average about 26. Therefore the total redd counts in this core area ranged between 28 to 87 since procedures were standardized. (Lewis 2012; page 114).

The range of redd numbers in the Wenatchee Core Area varies from 283 in 2001 to 706 in 2006. Since 2000, an average of 452 redds have been counted in the Wenatchee Core Area. This [is] greater than the 391 redds which existed for the Wenatchee populations in 1998 at the time of the listing. Overall, the trend for the Wenatchee Core Area seems to be stable and suggests a slightly increasing trend. (Lewis 2012; page 114).

Annual Spawning Abundance

Based on redd surveys, U. S. Fish and Wildlife Service estimated that the Methow Core Area had 304 adult migratory bull trout (estimated using an assumption of two adults per redd) (Lewis 2012).

The estimate for the Wenatchee Core Area was described in the BiOp:

Within the Wenatchee Core Area, the status review found that adfluvial and fluvial migratory bull trout are present as well as the resident form of bull trout. The review also found a high degree of connectivity within the core areas with the lower bound being the watershed boundary and the upper bounds being natural...
barriers and headwaters. Population size for the Wenatchee Core Area was identified as between 250-1,000 individuals. (Lewis 2012; page 74).

Annual Proportions of Hatchery Origin and Natural Origin Fish on the Spawning Grounds

There are no bull trout hatchery programs in the region. Therefore, this element does not apply to bull trout.

Juvenile Emigration Timing

Juvenile bull trout primarily rear in headwater streams, but have been observed in some locations in the Columbia River. They are occasionally encountered in smolt rotary screw traps. However, timing of emigration to the Columbia is not well understood. Juvenile bull trout have not been observed at Wells Dam (Lewis 2012). However, Lewis (2012) summarized information on juvenile bull trout encounters at other locations in the Mid-Columbia region:

…juvenile bull trout were observed at other smolt trapping facilities and adult ladders on the mainstem Columbia River. BioAnalysts, Inc. 2004, 2006, 2007, and 2008 also reported that 24, 17, 15, and 5 juvenile bull trout were observed passing upstream through the adult fishway at Rocky Reach Dam from April 14-November 1 for each year from 2006-2007, respectively. Observations of adult and juvenile bull trout within close proximity of fishway maintenance periods at Rocky Reach Dam have been noted as well. BioAnalysts, Inc. 2006 observed 1 adult bull trout at Rocky Reach dam in 2005 ascending the ladders in 2005 (November 15-December 4). BioAnalysts, Inc. (2007) reported one juvenile bull trout in the early season just following fishway maintenance on February 7, 2006 and 35 sub-adults that ascended the [sic] during the fall season (November 15-December 4th, 2006) typically when ladders would be shut off for maintenance activities. This is the highest recorded number for annual juvenile use of upstream fish ways/ladders recorded at Rocky Reach and in the Mid-Columbia area. (Lewis 2012; page 97).

Presence in the Columbia River

Adult and sub-adult bull trout have been observed in the Columbia River (Table 2.14), predominantly in May, June, and July (Figure 2.19). As described above, juvenile bull trout have been observed in the Columbia River, but are rare and have not been observed in the vicinity of Wells Dam or Hatchery. The BiOp reviewed the information on bull trout in the Columbia River, which is excerpted, below:

Downstream passage of juvenile anadromous fish at dams occurs through juvenile fish passage facilities, by spilling water over dam spillways, or traveling through the powerhouse turbines. Migratory sized bull trout are observed each year using the adult fish passage facilities to pass the Rocky Reach, Rock Island, and Wells dams... Despite observations of juvenile bull trout at lower river projects,
juveniles have not been observed at Wells Dam. Juvenile bull trout have been infrequently observed in the juvenile sampling facilities at these dams [Rocky Reach and Rock Island] as well. Bull trout were sampled in the Rocky Reach Dam prototype juvenile bypass collector in 1998, 1999, 2000, 2001, and 2002, with 23, 30, 8, 4, and 5 fish observed, respectively (Service 2004a). In 2003, no juvenile bull trout were sampled at the new Rocky Reach Dam juvenile collector sampling facility. Length measurements were not taken on these fish; however, anecdotal information from sampling facility personnel indicated that most were juvenile or sub-adult fish. Facility personnel could recall observing only two or three adult bull trout in the sampling facility during all years of prototype operation (S. Hemstrom, CPUD, pers. comm., 2003). Juvenile fish sampling in 2003 occurred for only 2 hours (8-10 am) each day, and also in the evening (4-6 pm and 7 to 9 pm) one day per week. It is probable that some juvenile and adult bull trout pass undetected at night during periods when the sampling facility is not operating. More recently, one juvenile bull trout has been observed in the juvenile fish bypass system at Rocky Reach each year from 2005-2007 (BioAnalysts, Inc. 2004, 2006, 2007, and 2008).

Numbers of bull trout captured at the Rock Island Bypass smolt trapping facility from 1997 through 2006 were 2, 7, 14, 1, 8, and 8, 2, 3, and 5 respectively (www.fpc.org, Service 2004a). From 1998-2006 there were a total of 18 juvenile bull trout (when only including actual juvenile data) captured at the Rock Island Dam smolt trap facility generally between June-August. No juvenile bull trout were captured in the Rock Island Juvenile Bypass trap in 2003 (L. Praye, WDFW, pers. comm., 2003). Additionally, between 1998 and 2007 there were an additional 30 bull trout observed generally between May-August (the size was not determined) at the Rock Island Bypass smolt trap facility. We assume that since adult bull trout are generally identified that these fish were either juvenile or sub-adult bull trout. Most of the bull trout captured at the Rock Island smolt bypass are small bull trout. (Lewis 2012; page 96).

Although observations of juvenile and sub-adult fish have not occurred at Wells dam [sic], adult fish pass Wells in the month of May and June (90%). Adult counts occur year round at Wells dam [sic]. Since 1998 to 2011 adult bull trout counts at Wells dam have ranged between 17-108 fish, with the 13 year average being 61 fish and the most recent ten year average being slightly higher at 63 fish… (Lewis 2012; page 97).

Results of the telemetry studies identified several notable bull trout life history characteristics. Within the Mid-Columbia Basin, bull trout utilized the mainstem Columbia River as a migratory corridor as data indicated that tagged fish passed through the Mid-Columbia projects (BioAnalysts, Inc. 2004). This establishes that
bull trout may be in the mainstem Columbia River (i.e., Wells Reservoir) throughout the year.

Within the Wells Project area, the majority of radio-tagged bull trout were destined for the Twisp and Methow rivers located upstream of Wells Dam (86-88%), however some fish also migrated into the Entiat River (10-12%), which is located downstream of Wells Dam. Most of the radio-tagged bull trout passed Wells Dam during the months of May and June (BioAnalysts, Inc. 2004). Adults generally concluded spawning in the Methow by late October; some bull trout were observed returning to Wells Reservoir by mid-December. Bull trout did not select the Okanogan River system in both telemetry studies (one bull trout entered the Okanogan for a short period before leaving to enter the Methow system). PIT tag data from 2004-2011 suggests that only 17% (30 of 177) of Methow Core Area fish use Lake Pateros, and only 2% (3 of 177) use lake Entiat [sic]. A similar proportion, 15% (2/13) of radio tagged fish appear to overwinter in Lake Pateros (MCRFRO 2004…).” (Lewis 2012; page 81).

Table 2.14. Tabulated summary of bull trout passage up adult fish ladders at three mid-Columbia projects (FPC.org) (Lewis 2012; page 99).

<table>
<thead>
<tr>
<th></th>
<th>Rocky Reach</th>
<th>Rock Island</th>
<th>Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>83</td>
<td>67</td>
<td>17</td>
</tr>
<tr>
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<td>128</td>
<td>61</td>
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<td>2000</td>
<td>216</td>
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<td>204</td>
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<tr>
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<td>161</td>
<td>114</td>
<td>47</td>
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<tr>
<td>2005</td>
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</tr>
<tr>
<td>2010</td>
<td>124</td>
<td>53</td>
<td>44</td>
</tr>
<tr>
<td>2011</td>
<td>168</td>
<td>49</td>
<td>66</td>
</tr>
<tr>
<td>13 Year Average</td>
<td>148.6</td>
<td>67.5</td>
<td>60.9</td>
</tr>
<tr>
<td>10 Year Average</td>
<td>150.4</td>
<td>66.4</td>
<td>63.1</td>
</tr>
</tbody>
</table>
Figure 2.19. Seasonal distribution of adult bull trout observations at Wells Dam for the years 1998-2011 (DCPUD 2012).

Citations from excerpted material


Personal Communications


2.2.4 Describe Hatchery Activities, Including Associated Monitoring and Evaluation and Research Programs, that may Lead to the Take of ESA-listed Fish in the Target Area, and Provide Estimated Annual Levels of Take.

2.2.4.1 Hatchery Program Activities

Hatchery program activities include:

- Collection of broodstock (up to 602 adult summer Chinook) through trap operations at Wells Dam and Wells Hatchery. Trapping may incidentally capture listed fish. All incidentally trapped non-target fish will be released unharmed immediately.
- Release of up to 484,000 (+/-10%) subyearling and 320,000 (+/-10%) yearling summer Chinook smolts into the Columbia River. Potential for interaction with listed fish in the Columbia River.
- Monitoring of the programs in the hatchery environment using standard techniques such as growth and fish health sampling. Slight potential for interaction with listed steelhead in the hatchery environment.

2.2.4.2 Adult Management Activities

Hatchery origin summer Chinook that volunteer to Wells Hatchery will be retained. Trapping may incidentally capture listed fish. All incidentally trapped non-target fish will be released unharmed immediately.

2.2.4.3 Responsibilities

The funding entity, permit holder, and agent for the activities discussed in this section are as follows:

2.2.4.4 Harvest

*Funding:* WDFW

*Permit Holder:* WDFW

*Agent:* WDFW

2.2.4.5 Adult Removal at Trapping Facilities

WDFW is responsible for coordinating the funding for manual adult management activities from the point at which fish are placed in holding containers when removed and/or for any fisheries on returning adults from the Wells Hatchery summer Chinook program (see “Harvest” above). The Co-Managers will determine the disposition of the fish placed in the holding containers.

*Permit Holder:* Douglas PUD and WDFW will be co-permit holders for adult management activities up to the point at which summer Chinook are removed from Douglas PUD’s trapping
facilities and placed in holding containers. WDFW will be the permit holder for manual adult management activities from the point at which fish are removed from Douglas PUD’s trapping facilities and placed in holding containers. WDFW will also hold permits for any fisheries on adults returning from the Wells Hatchery summer Chinook program.

Agent: For Douglas PUD’s permit, WDFW is designated as the authorized agent under a current contract between Douglas PUD and WDFW and until this contract expires and is not renewed or renegotiated.

3.0 RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES

3.1 Describe Alignment of the Hatchery Program with any ESU-wide Hatchery Plan or Other Regionally Accepted Policies. Explain any Proposed Deviations from the Plan or Policies

The objectives of the Wells Hatchery summer Chinook artificial propagation program are established in the Wells HCP and described above in Section 1.

3.1.1 HSRG – Upper Columbia Review

The Hatchery Scientific Review Group (HSRG), as part of the Pacific Salmon Hatchery Reform Project, has completed a review of 178 hatchery programs and 351 salmonid populations in the Columbia River Basin. The project was conducted by the Columbia River HSRG, composed of 14 members, nine of whom were affiliated with agencies and tribes in the Columbia River Basin. The remaining five members were unaffiliated biologists. The objective was to produce recommendations for hatchery reform based on broad policy agreements and supported by consistent technical information about hatcheries, habitat, and harvest. The Upper Columbia Hatchery Programs Regional Review began in April 2008, and the final HSRG recommendations were published January 31, 2009 in Appendix E to the Columbia River Hatchery Reform System-Wide Report (HSRG 2009). The principles of the HSRG recommendations were taken into account when developing this HGMP.

3.2 List All Existing Cooperative Agreements, Memoranda of Understanding, Memoranda of Agreement, or other Management Plans or Court Orders under which the Program Operates

3.2.1 Wells Habitat Conservation Plan

In April 2002, pursuant to section 10(a)(1)(B) of the ESA, negotiations on the Anadromous Fish Agreement and Habitat Conservation Plan Wells Hydroelectric Project FERC License No. 2149 with Douglas PUD for the operation of Wells Dam (HCP, DPUD 2002) were concluded. A Biological Opinion with incidental take statements (ITSs) on the operation of the Wells Hydroelectric Project was issued consistent with the HCP (NMFS 2003a, 2003b, 2003c). The
Incidental Take Permit No.1347 (NMFS 2003a) added Douglas PUD to the permit for summer Chinook production as a joint permit holder with WDFW and Chelan PUD in accordance with Douglas PUD’s HCP Agreement reached between Douglas PUD, NMFS, USFWS, WDFW, CCT, YN, and the Power Purchasers⁶. The artificial propagation activities of this program are included within Douglas PUD’s HCP; see Sections 1.7 and 1.8 for more detailed information regarding the HCPs. The production levels specified in the HGMP are identical to those of the HCP; therefore this HGMP is consistent with the Wells HCP.

3.2.2 2008-2017 / United States v. Oregon / Management Agreement

The purpose of this Management Agreement is to provide a framework within which the signatory fishery Co-Managers can use their authorities to protect, rebuild, and enhance UCR fish runs while fairly sharing harvestable fish between Treaty and non-Treaty fisheries. The Management Agreement specifies harvest limits and artificial production measures for stocks of salmon and steelhead originating above Bonneville Dam. The hatchery production goal for the Wells Hatchery summer Chinook as shown in Appendix B Table B2 of the Management Agreement is 320,000 yearlings and 484,000 subyearlings incubated and reared at the Wells Hatchery. The mitigation production levels specified in this HGMP are identical to those of the Management Agreement; therefore this HGMP is consistent with US v. Oregon.

This program does not affect the management, assessment, or goals of fisheries that occur outside of the Upper Columbia River basin. Impacts of ocean fisheries are regulated under authority of the Pacific Salmon Commission and the Pacific Fishery Management Council. Mainstem Columbia River fisheries are regulated under a co-management framework pursuant to litigation in US v Oregon.

3.3 Describe Fisheries Benefiting from the Program, and Indicate Harvest Levels and Rates for Program-origin Fish for the Last Twelve Years (1998-2009), if Available

The fisheries benefiting from this program include:

- Ocean recreational and commercial fisheries from the mouth of the Columbia River north to S.E. Alaska
- Columbia River Zone 1-5 commercial fishery
- Columbia River Zone 1-6 recreational fishery
- Columbia River Zone 6 tribal C&S and commercial fisheries
- Mid-Columbia River recreational fisheries
- Upper Columbia and Okanogan rivers Colville Tribal C&S fisheries
- Upper Columbia and Okanogan rivers recreational fisheries

⁶ Entities that have executed long-term power sales contracts with Douglas PUD, specifically Puget Sound Energy, Inc., Portland General Electric, PacifiCorp., and Avista Corp.
Harvest of Wells summer Chinook has averaged 58% (SD = 19) between brood years 1992 and 2003, but in more recent years (1997 to 2003) has averaged 72% (Table 3.1). Despite high harvest rates, no relationship was detected between harvest rates and the ability to meet the broodstock collection goal, indicating that the high harvest rates did not limit broodstock collection.

Table 3.1. Harvest rates of Wells Summer Chinook (Murdoch et al. 2012).

<table>
<thead>
<tr>
<th>Brood year</th>
<th>Broodstock Goal</th>
<th>Broodstock Collected</th>
<th>% Collected</th>
<th>Harvest rate</th>
</tr>
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<tbody>
<tr>
<td>1992</td>
<td>179</td>
<td>205</td>
<td>115</td>
<td>0.26</td>
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<td>1993</td>
<td>434</td>
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<td>434</td>
<td>440</td>
<td>101</td>
<td>0.33</td>
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<td>1995</td>
<td>434</td>
<td>365</td>
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<tr>
<td>1998</td>
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<tr>
<td>1999</td>
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<td>100</td>
<td>0.83</td>
</tr>
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<td>0.69</td>
</tr>
<tr>
<td>2001</td>
<td>443</td>
<td>458</td>
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<td>0.65</td>
</tr>
<tr>
<td>2002</td>
<td>443</td>
<td>447</td>
<td>101</td>
<td>0.66</td>
</tr>
<tr>
<td>2003</td>
<td>443</td>
<td>368</td>
<td>83</td>
<td>0.67</td>
</tr>
</tbody>
</table>

### 3.4 Relationship to Habitat Protection and Recovery Strategies

This is a segregated program designed to contribute to harvest opportunity. It is not related to habitat protection or recovery strategies.

### 3.5 Ecological Interactions

Potential effects of the Wells Hatchery summer Chinook program on salmonids and non-salmonids as well as the physical environment, and potential effects of other supplementation programs, natural-origin fish, and other species on this summer Chinook hatchery program, have been evaluated in the NMFS Biological Opinion (2003a) for a multi-year authorization for an annual take of UCR spring Chinook salmon and UCR steelhead associated with the summer Chinook supplementation program (Permit 1347). Potential effects from the program are regulated by existing policies regarding hatchery operations, maintenance protocols, fish health practices, genetic effects, ecological interactions, and fish cultural practices, as prescribed in the 1994 Integrated Hatchery Operations Team annual report (IHOT 1995).

#### 3.5.1 Populations that Could Negatively Impact the Program

Juvenile hatchery summer Chinook salmon are liberated as yearling and subyearling juveniles through volitional releases. Fish, mammals, and birds are the primary natural predators of summer Chinook in the Upper Columbia Basin. Several fish species may consume summer
Chinook. Northern pikeminnow (*Ptychocheilus oregonensis*), walleyes (*Sander vitreus vitreus*), and smallmouth bass (*Micropterus dolomieu*) have the potential to negatively affect the abundance of juvenile Chinook (Gray and Rondorf 1986; Bennett 1991; Burley and Poe 1994). Adult salmonids within the Upper Columbia Basin are opportunist feeders and are therefore capable of preying on juvenile summer Chinook. Those adult salmonids likely to have some effect on the survival of juvenile salmonids include (in order of greatest likely impact), adult bull trout, rainbow trout, cutthroat trout, and brown trout.

Predation by piscivorous birds on juvenile salmonids may also represent a large source of mortality. The NMFS (2000) identified gulls (*Larus* spp.), cormorants (*Phalacrocorax* spp.), and Caspian terns (*Sterna caspia*) as the most important avian predators in the Columbia River Basin. In the Columbia River estuary, avian predators consumed an estimated 16.7 million smolts (range, 10-28.3 million smolts), or 18 percent (range, 11 to 30 percent), of the smolts reaching the estuary in 1998 (Collis et al. 2000). Caspian terns consumed primarily salmonids (74 percent of diet mass), followed by double-crested cormorants (*P. auritus*) (21 percent of diet mass) and gulls (8 percent of diet mass).

Predation and delayed mortality for returning adult salmon as a result of wounding by marine mammals may negatively affect summer Chinook salmon. The incidence of wounds noted at Lower Granite Dam during 1991 was 20.9 percent for adult spring migrants and 9.4 percent for summer migrant salmon (Park 1993). In 1992, the numbers were 17.4 percent and 7.6 percent, respectively. Although UCR Chinook do not pass Lower Granite Dam, the losses there may be similar to losses experienced by UCR Chinook along their migration route.

Competition and potentially predation could also occur between juvenile summer Chinook and hatchery steelhead that reside in the mainstem Columbia River. Competition for food and space with other hatchery released fish (e.g., coho salmon) throughout the Columbia Basin may occur as hatchery summer Chinook rear and migrate downstream through the Columbia River.

Both introduced (e.g., walleye and smallmouth bass) and native predators (e.g., northern pikeminnow) consume large numbers of juvenile salmonids as they migrate through the Columbia River system (Poe et al. 1991; Rieman et al. 1991; Tabor et al. 1993). Exacerbating this impact of predation are observations that northern pikeminnow are able to rapidly adjust their diet and foraging habits to key in on the opportunity presented by the release and seaward migration of large numbers of hatchery fish (Shively et al. 1996). Furthermore, pikeminnow predation is typically concentrated downstream of mainstem hydropower facilities where juvenile fish are less dispersed than normal, and potentially disoriented and/or stressed following navigation through the hydro facility. Ongoing programs designed to control the size of predator populations and to redesign juvenile bypass facilities to avoid the aggregation of large numbers of predators below mainstem dams are attempting to minimize the impacts of predation and increase the survival of seaward migrating juvenile salmonids.
3.5.2 Populations that Could be Negatively Impacted by Program

See Section 2.

3.5.3 Populations that Have a Positive Impact on the Program

Not applicable.

3.5.4 Populations Positively Impacted by the Program

See Section 3.5 item 1.

4.0 WATER SOURCE

4.1 Provide a Quantitative and Narrative Description of the Water Source (Spring, Well, Surface), Water Quality Profile, and Natural Limitations to Production Attributable to the Water Source

Wells Hatchery uses surface water from the Columbia River and ground water from areas surrounding the hatchery. Douglas PUD has a single well field groundwater right with a combined 17,060 gallons per minute (gpm) for use by Wells Hatchery. Wells Hatchery groundwater temperatures peak at 14°C by September and October, then cool to 8.0 to 9.0°C by spring. Surface water is provided via a 150-cubic-feet-per-second (cfs)-capacity water line from the forebay of Wells Dam. Surface-water temperatures peak at 19.4°C in August and September, and cool to 2.2°C by February. Surface water is used in various stages of rearing, once fungal load and temperatures decline to at or below 10°C in late fall / early winter. Surface water used by the hatchery is included under the surface-water right for power generation by Wells Dam.

4.2 Indicate Risk Aversion Measures that will be Applied to Minimize the Likelihood for the Take of Listed Natural Fish as a Result of Hatchery Water Withdrawal, Screening, or Effluent Discharge

Water withdrawal for use in hatcheries is monitored through the Washington State Department of Ecology and the Washington State chapter 90.03 Revised Code of Washington (RCW) water code. None of the hatchery facilities employed to carry out the proposed artificial propagation programs de-water river reaches used by listed fish for migration, spawning, or rearing. The screen on the surface-water intake for Wells Hatchery was replaced in early 2008. The new screen complies with the 1995 NMFS screening criteria and as per the 1996 addendum to those criteria (NMFS 1996).
All WDFW hatcheries monitor their discharge in accordance with the National Pollutant Discharge Elimination System (NPDES) permit. This permit is administered in Washington by the Washington State Department of Ecology under agreement with the EPA. The permit was renewed effective August 1, 2010 and will expire August 1, 2015. Hatchery wastewater discharge is monitored monthly at each of the steelhead and spring Chinook production facilities in the Upper Columbia Basin. The WDFW-operated facilities include Methow Hatchery and Wells Hatchery (as well as Eastbank Hatchery, Chiwawa Ponds, Chelan Hatchery and Turtle Rock Hatchery). No violations of the NPDES permit limits occurred during the reporting period June 1, 2009 through March 2013. Facilities are exempted from sampling during any year that production of fish falls below 20,000 pounds, or pounds of feed used in a month fall below 5,000 pounds, with the exception of offline settling basin discharges, which are to be monitored once per month when ponds are in use and discharging to receiving waters.

Sampling at permitted facilities includes the following parameters:

- **FLOW**: Measured in millions of gallons per day (MGD) discharge.
- **SS EFF**: Average net settleable solids in the hatchery effluent, measured in milliliters per liter (ml/L).
- **TSS COMP**: Average net total suspended solids, composite sample (6 x/day) of the hatchery effluent, measured in milligrams per liter (mg/L).
- **TSS MAX**: Maximum daily net total suspended solids, composite sample (6 x/day) of the hatchery effluent, measured in mg/L.
- **SS PA**: Maximum settleable solids discharge from the pollution abatement pond, measured in ml/L.
- **SS %**: Removal of settleable solids within the pollution abatement pond from inlet to outlet, measured as a percent. No longer required under permit effective June 1, 2000.
- **TSS PA**: Maximum total suspended solids effluent grab from the pollution abatement pond discharge, measured in mg/L.
- **TSS %**: Removal of suspended solids within the pollution abatement pond from inlet to outlet, measured as a percent. No longer required under permit effective June 1, 2000.
- **SS DD**: Settleable solids discharged during drawdown for fish release. One sample per pond drawdown, measured in ml/L.
- **TRC**: Total residual chlorine discharge after rearing vessel disinfection and after neutralization with sodium thiosulfate. One sample per disinfection, measured in micrograms per liter (µg/L).

### 5.0 FACILITIES

#### 5.1 Broodstock Collection Facilities (or methods)

Broodstock collection facilities consist of the Wells Hatchery volunteer channel and the Wells Dam east and west fish ladder traps, if needed. The volunteer channel is the primary source for Wells Hatchery broodstock.
5.2 Fish Transportation Equipment (Description of Pen, Tank Truck, or Container Used)

Not required. Fish are collected, reared, acclimated, and released on-station.

5.3 Broodstock Holding and Spawning Facilities

IHOT adult holding guidelines are followed for adult holding, density, water quality, alarm systems and predator control measures to provide the necessary security for the broodstock. Broodstock are held in a concrete raceway and adults are seined, sorted, killed and spawned at spawning facilities integrated into the concrete raceway (Table 5.1).

Table 5.1. Broodstock Holding and Spawning Facilities.

<table>
<thead>
<tr>
<th>Ponds (No.)</th>
<th>Pond Type</th>
<th>Volume (cu. ft)</th>
<th>Length (ft)</th>
<th>Width (ft)</th>
<th>Depth (ft)</th>
<th>Available Flow (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Channel Pond- Lower 15 at Wells Hatchery</td>
<td>12,232</td>
<td>139</td>
<td>19</td>
<td>4</td>
<td>1,850</td>
</tr>
<tr>
<td>1</td>
<td>Channel Pond- Upper 15 at Wells Hatchery</td>
<td>16,500</td>
<td>200</td>
<td>19</td>
<td>3.9</td>
<td>1,850</td>
</tr>
</tbody>
</table>

5.4 Incubation Facilities

Table 5.2. Incubation Facilities.

<table>
<thead>
<tr>
<th>Incubator Type</th>
<th>Units (number)</th>
<th>Flow (gpm)</th>
<th>Volume (cu. ft)</th>
<th>Loading-Eyeing (eggs/unit)</th>
<th>Loading-Hatching (eggs/unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heath Vertical – 52 Half Stack Units at 7 trays per ½ Stack</td>
<td>52</td>
<td>3 - 5</td>
<td>1 female, 4,500</td>
<td>5,500</td>
<td></td>
</tr>
</tbody>
</table>

5.5 Rearing Facilities

See Section 5.6 below.

5.6 Acclimation/release Facilities

Table 5.3. Rearing/Acclimation/Release Facilities.

<table>
<thead>
<tr>
<th>Ponds (No.)</th>
<th>Pond Type</th>
<th>Volume (cu. ft)</th>
<th>Length (ft)</th>
<th>Width (ft)</th>
<th>Depth (ft)</th>
<th>Flow (gpm)</th>
<th>Max. Flow Index</th>
<th>Max. Density Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Concrete Raceways</td>
<td>2,474</td>
<td>93.5</td>
<td>9.8</td>
<td>2.7</td>
<td>400</td>
<td>1.8</td>
<td>0.12</td>
</tr>
<tr>
<td>4</td>
<td>Concrete Raceways</td>
<td>3,459</td>
<td>97.4</td>
<td>9.8</td>
<td>3.6</td>
<td>400</td>
<td>1.8</td>
<td>0.12</td>
</tr>
<tr>
<td>1</td>
<td>Earthen-Sand Pond (DP-1)</td>
<td>176,000</td>
<td>440</td>
<td>100</td>
<td>4.0</td>
<td>2,500</td>
<td>1.8</td>
<td>0.12</td>
</tr>
<tr>
<td>1</td>
<td>Earthen-Sand Pond (DP-2)</td>
<td>320,160</td>
<td>667</td>
<td>120</td>
<td>4.0</td>
<td>3,500</td>
<td>1.8</td>
<td>0.12</td>
</tr>
</tbody>
</table>
5.7 Describe Operational Difficulties or Disasters that Led to Significant Fish Mortality

In November 2002, approximately 50 percent of the BY 2001 summer Chinook were loss due to *Ichthyophthirius* outbreak. The subyearling program has experienced coagulated yolk with up to 20 to 25% mortality. The subyearling program is incubated under ambient well water temperatures. Chilling the subyearling program may not be feasible because it would delay their development and growth to a point where they are not suitable for release at age 0.

5.8 Indicate Available Back-up Systems, and Risk Aversion Measures that Will Be Applied, that Minimize the Likelihood for the Take of Listed Natural Fish that May Result from Equipment Failure, Water Loss, Flooding, Disease Transmission, or other Events that Could Lead to Injury or Mortality

Potential adverse impacts identified with the physical operation of hatchery facilities include impacts from water withdrawal, release of hatchery effluent and facilities failure (NMFS 1999). Hatchery effluent may transport pathogens (disease) out of the hatchery and infect natural-origin fish. Aside from the potential impacts on water flow and quality, operational failures due to power/water loss, flooding, freezing, vandalism, predation, and disease may result in catastrophic losses to rearing adults and juveniles; however those losses would not affect listed natural fish.

Flow reductions, flooding, and poor fish-culture practices may all cause hatchery facility failure or the catastrophic loss of fish under propagation; although the fish propagated under the Wells Hatchery summer Chinook program are not listed. Nevertheless, a variety of measures to address risks associated with operational failures will be used, including:

- Protection of fish from vandalism and predation is provided by fencing, locks, and security lights at all hatchery facilities.
- Rapid response in the event of power and water loss or freezing is provided by a combination of staffing and automated alarm paging systems.
- Equipping hatchery facilities to ensure reliable power to provide water to rearing fish during power outages. Wells FH was recently equipped with diesel backup generation to the dual power supplies (local dam feed to most facilities, plus Chelan PUD feed to the lower rearing ponds) to ensure reliable power to provide water to rearing fish even during a dual power outage.

6.0 BROODSTOCK ORIGIN AND IDENTITY

Describe the origin and identity of broodstock used in the program, its ESA-listing status, annual collection goals, and relationship to natural-origin fish of the same species/population.
6.1 Source

Since the initial operation of the Wells Hatchery spawning channel in 1967, broodstock collected for Wells Hatchery has come from fish diverted out of fish ladders while passing Wells Dam or from volunteers that enter the trap at the upper end of the hatchery discharge (Chapman et al. 1994). With the exception of undetected strays from other areas that may have contributed to the Wells broodstock collections, and the potential incorporation in some years (1967-86) of fall-run Chinook, all broodstock for the Wells Hatchery program came from local Columbia River summer Chinook stock (Chapman et al. 1994). Since founding the Wells summer Chinook program from trapped Methow/Okanogan natural fish, there has been a transition to the use of mixed natural and hatchery-origin volunteer broodstock at Wells Hatchery for the Wells program.

Methow and Okanogan basin summer Chinook were the major populations intercepted at Wells Dam, supplying broodstock for the program. Chinook salmon broodstock for Wells Hatchery has routinely been collected primarily from volunteers to the hatchery, and secondarily from the fishways at Wells Dam. Trap operations terminate on 31 August, which virtually eliminated all known fall Chinook salmon from the Wells broodstock, as determined by subsequent coded-wire tag analyses.

Since the inception of Wells Hatchery in 1967, less than 25% of the summer Chinook salmon run (adults and jacks) to Wells Dam were collected for broodstock, both as volunteers and on the west fishway. In some years however, collections included egg-take needs for Entiat National Fish Hatchery, the Yakama Nation, Turtle Rock/Chelan Falls program, and to support a triploid Chinook program for Lake Chelan. Most fish used for production were from volunteer returns to the hatchery. From 1985 to 1993, 77% of the summer Chinook used at Wells Hatchery were volunteers. Currently, 100% of the broodstock are volunteers to Wells Hatchery.

6.2 Supporting Information

6.2.1 History

Summer Chinook broodstock collected for the hatchery programs are the descendants of stock manipulations during the Grand Coulee Fish Maintenance Program and mainstem dam mitigation (Myers et al. 1998). These activities tended to homogenize extant summer Chinook populations, and likely resulted in incorporation of fall-run fish into summer Chinook populations under propagation. The percentage of non-indigenous stocks incorporated into the hatchery programs has been low (about 3% of the over 200 million ocean-type Chinook propagated since 1941), and does not appear to have had a significant impact on the genetic integrity of the ESU (Chapman et al. 1994; Myers et al. 1998).

Propagation of summer/fall Chinook in the Columbia Cascade Province started with operation of the Wells spawning channel in 1967. Initially, the entire temporal distribution of the run, through early November (S. Bickford, personal communication, 2003) was represented in the broodstock. Beginning in 1987, broodstock collection was terminated after August 28th to avoid including stray fall Chinook from downriver programs. All broodstock came from local Columbia River
summer/fall Chinook stock with few exceptions. Broodstock was captured from ladders at Wells Dam or from volunteers that entered the trap at the hatchery outfall. Only low numbers, about 3%, of non-indigenous stocks have been incorporated into the broodstock over the years. Methow and Okanogan sub-basins were the major populations intercepted at Wells Dam and collected for broodstock.

Both Waknitz et al. (1995) and Kassler et al. (2011) found that summer/fall Chinook in the upper Columbia, including the Wells Hatchery stock, Wenatchee, Methow, and Similkameen/Okanogan populations show no genetic differentiation. Mainstem spawners above Wells Dam have not been analyzed as a discrete group, in part due to the fact that it was uncertain if mainstem spawning occurred above Wells Dam, and in part because it is not possible to differentiate such fish from the other populations at sampling locations. However, mainstem spawners ranging from McNary Dam to Chief Joseph Dam are considered to be a spawning aggregate that is not differentiated from other populations. Therefore, a mainstem spawning group is likely to follow the same pattern of genetic non-differentiation as observed in the other nearby spawning aggregates. This is particularly true given the history of stock management in the region (see Waknitz et al. [1995] for more detailed discussion of this topic).

6.2.2 Annual size

See Section 1.12.

6.2.3 Past and Proposed Level of Natural Fish in Broodstock

Up to 10% of the broodstock for the Wells hatchery summer Chinook program were comprised of natural origin fish. The HSRG (2009) recommended a segregated program for the Wells Hatchery summer Chinook if the mainstem spawners are not a distinct population (see Section 6.2.1). However, to maintain continuity with the natural population, the proposed level of natural origin fish in the broodstock is up to 10% of the total broodstock. The HCP Hatchery Committee must approve collection of broodstock in excess of 10% natural-origin fish.

6.2.4 Genetic or Ecological Differences

The Wells summer Chinook broodstock and hatchery population was derived from local stocks and continues to integrate local stocks at a low level to maintain genetic continuity with local natural populations.

6.2.5 Reasons for Choosing

The broodstock source was chosen to represent the populations upstream of Wells Dam, consistent with the location of Wells Hatchery.
6.3 Indicate Risk Aversion Measures that will be Applied to Minimize the Likelihood for Adverse Genetic or Ecological Effects to Listed Natural Fish that May Occur as a Result of Broodstock Selection Practices

The broodstock protocols were designed to mitigate for potential genetic effects from hatchery domestication and to avoid introgression with fish from other spawning aggregates.

7.0 BROODSTOCK COLLECTION

7.1 Life-history Stage to be Collected (adults, eggs, or juveniles)

Adults will be collected as broodstock.

7.2 Collection or Sampling Design

Broodstock will be collected across the run to ensure representation of the population and reduce the potential for inadvertent selection. Broodstock collection will not exceed collection thresholds for wild fish (<33%).

7.3 Identity

Hatchery origin fish are identified by excised adipose fin and CWT.

7.4 Proposed Number to be Collected

Up to 602 adults.

7.4.1 Program Goal (assuming 1:1 sex ratio for adults)

7.4.2 Broodstock Collection Levels for the Last Twelve Years, or for Most Recent Years Available
Table 7.1. Wells hatchery summer Chinook broodstock collection 2000-2012. Collections were for the Wells Hatchery yearling and subyearling programs, Turtle Rock program, Yakama Nation Yakima River reintroduction program, Entiat National Fish Hatchery, Chelan Falls program, and the Lake Chelan triploid program.

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Adults Collected</th>
<th>Pre-Spawn Mortality</th>
<th>Females Spawned</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>726</td>
<td>21</td>
<td>375</td>
</tr>
<tr>
<td>2011</td>
<td>1,132</td>
<td>45</td>
<td>545</td>
</tr>
<tr>
<td>2010</td>
<td>1,094</td>
<td>50</td>
<td>388</td>
</tr>
<tr>
<td>2009</td>
<td>1,502</td>
<td>55</td>
<td>735</td>
</tr>
<tr>
<td>2008</td>
<td>1,424</td>
<td>48</td>
<td>640</td>
</tr>
<tr>
<td>2007</td>
<td>1,287</td>
<td>21</td>
<td>533</td>
</tr>
<tr>
<td>2006</td>
<td>1,251</td>
<td>36</td>
<td>559</td>
</tr>
<tr>
<td>2005</td>
<td>1,274</td>
<td>54</td>
<td>573</td>
</tr>
<tr>
<td>2004</td>
<td>1,181</td>
<td>40</td>
<td>497</td>
</tr>
<tr>
<td>2003</td>
<td>1,206</td>
<td>62</td>
<td>570</td>
</tr>
<tr>
<td>2002</td>
<td>1,295</td>
<td>115</td>
<td>570</td>
</tr>
<tr>
<td>2001</td>
<td>1,301</td>
<td>94</td>
<td>524</td>
</tr>
<tr>
<td>2000</td>
<td>1,206</td>
<td>83</td>
<td>556</td>
</tr>
</tbody>
</table>

7.5 Disposition of Hatchery-origin Fish Collected Surplus to Broodstock Needs

Surplus fish are the responsibility of WDFW and will be made available to Native American Tribes, food banks, used for nutrient enhancement or other measures as appropriate.

7.6 Fish Transportation and Holding Methods and Holding of Fish, Especially if Captured Unripe or as Juveniles. Include Length of Time in Transit

No transportation used.

Fish held in adult holding ponds. See Section 5.

7.7 Describe Fish Health Maintenance and Sanitation Procedures Applied

For all production programs under the Mid-Columbia Hatchery Program, standard fish-health monitoring will be conducted (monthly checks of salmon and steelhead) by a fish-health specialist, with intensified efforts to monitor presence of specific pathogens that are known to occur in the donor populations. Significant fish mortality attributed to an unknown cause(s) will
be sampled for histopathological study. Fish-health maintenance strategies are described in Integrated Hatchery Operations Team (IHOT 1995). Incidence of viral pathogens in salmon and steelhead broodstock will be determined by sampling fish at spawning in accordance with the Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Populations of particular concern may be sampled at the 100-percent level and may require segregation of eggs/progeny in early incubation or rearing, and/or culling. Specifically, incidence of *Renibacterium salmoninarum* (Rs, causative agent of Bacterial Kidney Disease [BKD]) in salmon broodstock will be determined by sampling fish at spawning by enzyme-linked immunosorbent assay (ELISA). Hatchery staff will segregate eggs/progeny based on levels of Rs antigen, protecting negative or low-ELISA progeny from the potential horizontal transmission of Rs bacteria from high-ELISA progeny. Progeny of any segregation study will also be tested by ELISA; at a minimum each segregation group would be sampled at release. Necropsy-based condition assessments (based on organosomatic indices) will be used to assess condition of hatchery-reared salmon smolts at release, and natural-origin salmon during outmigration. If needed, condition assessments will be performed at other key times during hatchery rearing.

7.8 Disposition of Carcasses

IHOT, Pacific Northwest Fish Health Protection committee (PNFHPC), state or tribal guidelines are followed for broodstock fish health inspection, transfer of eggs or adults and broodstock holding and disposal of carcasses. Carcasses of the fish spawned in captivity may be used for nutrient enrichment if disease protocols as determined by the Co-Managers fish-health specialists are met, donated for educational purposes, incinerated, or disposed of at waste disposal facilities.

7.9 Indicate Risk Aversion Measures that will be Applied to Minimize the Likelihood for Adverse Genetic or Ecological Effects to Listed Natural Fish Resulting from the Broodstock Collection Program

Broodstock will be collected form the Wells Hatchery volunteer channel. This will greatly minimize encounters with non-target fish. Non-target fish that are encountered will be released unharmed. If Wells Dam must be used as a trapping facility, trap operators can select which fish to trap, reducing capture of non-target fish. Non-target fish that are captured will be released unharmed.
8.0 MATING

8.1 Describe Fish Mating Procedures that will be Used, Including Those Applied to Meet Performance Indicators Identified Previously

8.1.1 Selection Method

All males and females collected for broodstock will be examined weekly during the spawning season to determine ripeness, and all fish will be spawned when ripe.

8.1.2 Males

Males may be live-spawned on the first spawning day as necessary to make up for a low naturally-occurring male to female ratio. However, inclusion of jack Chinook in the run-at-large broodstock collections helps to alleviate occasional shortages of adult males. Collecting jacks in similar proportions to the run-at-large ensures that the hatchery broodstock remains genetically similar to, and representative of, the up-river summer Chinook populations. However, the rate of inclusion of age-s males (i.e., “jacks”) will be based on and adjusted according to the evolving research in this area.

8.1.3 Fertilization

The spawning protocol employs a matrix spawning with one primary and one backup male. The eggs of one female are fertilized by the primary male. After a short time period to allow fertilization to occur, milt from a backup male (as available) is introduced to ensure fertilization in case the primary male was not viable. The primary male may be used as a backup male reciprocally to the original backup male, which is used as a primary male to fertilize the eggs of another female.

8.1.4 Cryopreserved Gametes

Cryopreserved gametes are not used.

8.2 Indicate Risk Aversion Measures that will be Applied to Minimize the Likelihood for Adverse Genetic or Ecological Effects to Listed Natural Fish Resulting from the Mating Scheme

Not applicable. Summer Chinook are not listed.

9.0 INCUBATION AND REARING

9.1 Specify Any Management Goals (e.g., “egg to smolt survival”) that the Hatchery is Currently Operating under for the
Hatchery Stock in the Appropriate Sections Below. Provide Data on the Success of Meeting the Desired Hatchery Goals

9.1.1 Incubation

9.1.1.1 Number of Eggs Taken and Survival Rates to Eye-up and/or Ponding

Egg-take goals vary annually dependent upon the necessary level to adjust and compensate for changes in survival prior to release.

<table>
<thead>
<tr>
<th>Brood</th>
<th>Collection to spawning</th>
<th>Unfertilized egg to eyed</th>
<th>Eyed egg to ponding</th>
<th>30 d after ponding</th>
<th>100 d after ponding</th>
<th>Transport to release</th>
<th>Unfertilized egg to release</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard 90.0 female 85.0 male</td>
<td>92.0</td>
<td>98.0</td>
<td>97.0</td>
<td>93.0</td>
<td>90.0</td>
<td>95.0</td>
</tr>
<tr>
<td>2009</td>
<td>96.0 97.2 95.2</td>
<td>100</td>
<td>97.6</td>
<td>97.5</td>
<td>95.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2008</td>
<td>97.0 94.6 93.2</td>
<td>97.6</td>
<td>99.8</td>
<td>99.4</td>
<td>92.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2007</td>
<td>97.2 98.2 87.9</td>
<td>98.3</td>
<td>99.9</td>
<td>99.7</td>
<td>93.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2006</td>
<td>96.4 97.3 82.0</td>
<td>99.3</td>
<td>99.4</td>
<td>99.2</td>
<td>97.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2005</td>
<td>96.8 98.9 87.5</td>
<td>100.0</td>
<td>99.2</td>
<td>99.0</td>
<td>92.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2004</td>
<td>98.3 98.2 92.0</td>
<td>100.0</td>
<td>99.0</td>
<td>98.9</td>
<td>96.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2003</td>
<td>96.8 98.4 86.4</td>
<td>99.8</td>
<td>99.2</td>
<td>99.2</td>
<td>97.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2002</td>
<td>94.2 97.0 94.1</td>
<td>100.0</td>
<td>99.6</td>
<td>99.6</td>
<td>92.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2001</td>
<td>97.1 93.9 95.3</td>
<td>98.8</td>
<td>99.4</td>
<td>99.4</td>
<td>35.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2000</td>
<td>98.3 95.2 93.8</td>
<td>99.9</td>
<td>99.5</td>
<td>99.4</td>
<td>99.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1999</td>
<td>97.3 96.3 92.3</td>
<td>97.1</td>
<td>98.0</td>
<td>98.0</td>
<td>97.5</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Wells summer Chinook salmon yearling
Table 9.2. Hatchery life-stage survival-rate standards and level achieved (%) by stock and brood year for Wells subyearling summer Chinook, brood years 1999-2009.

<table>
<thead>
<tr>
<th>Brood</th>
<th>Collection to spawning</th>
<th>Unfertilized egg to eyed</th>
<th>Eyed egg to ponding</th>
<th>30 d after ponding</th>
<th>100 d after ponding</th>
<th>Ponding to release</th>
<th>Transport to release</th>
<th>Unfertilized egg to release</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>90.0 female 85.0 male</td>
<td>92.0</td>
<td>98.0</td>
<td>97.0</td>
<td>93.0</td>
<td>90.0</td>
<td>95.0</td>
<td>81.0</td>
</tr>
<tr>
<td>2009</td>
<td>- - -</td>
<td>94.9</td>
<td>98.6</td>
<td>92.0</td>
<td>86.9</td>
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<td>84.2</td>
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<td>82.2</td>
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<td>71.6</td>
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<td>98.4</td>
<td>94.3</td>
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<td>94.3</td>
<td>- -</td>
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<td>87.8</td>
<td>- -</td>
<td>75.3</td>
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<tr>
<td>2002</td>
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<td>99.9</td>
<td>88.1</td>
<td>87.3</td>
<td>87.1</td>
<td>- -</td>
<td>81.7</td>
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<tr>
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<td>- - -</td>
<td>94.6</td>
<td>100.0</td>
<td>95.6</td>
<td>94.2</td>
<td>94.1</td>
<td>- -</td>
<td>89.1</td>
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<tr>
<td>2000</td>
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<td>97.6</td>
<td>97.4</td>
<td>97.1</td>
<td>- -</td>
<td>91.4</td>
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<tr>
<td>1999</td>
<td>- - -</td>
<td>90.9</td>
<td>100.0</td>
<td>96.7</td>
<td>96.3</td>
<td>96.2</td>
<td>- -</td>
<td>87.5</td>
</tr>
</tbody>
</table>

Wells summer Chinook salmon subyearling

9.1.1.2 Cause for, and Disposition of Surplus Egg Takes

Permit conditions specify a maximum number of broodstock that can be collected as determined by expected pre-spawning survival of broodstock, fecundity, and survival-to-release of progeny. To facilitate achievement of the production target of 320,000 yearlings and 484,000 subyearlings, annual estimates of broodstock needs will be based on updated estimates of age, fecundity, and life-stage survival values. Therefore, surpluses at any life stage may result when one or several actual life-stage survival values exceed estimates used in calculating broodstock needs. In the case of surplus eggs or fish, the surplus will be supplied to another appropriate program or destroyed.

9.1.1.3 Loading Densities Applied During Incubation

IHOT species-specific incubation recommendations will be followed for water quality, flows, temperature, substrate, and incubator capacities. Incubation conditions are based on loading densities recommended by Piper et al. (1982).

9.1.1.4 Incubation Conditions

Eggs are incubated full-term (green egg to emergence) at the Wells Hatchery.
9.1.1.5  Ponding

Summer Chinook fry are transferred from incubation trays for ponding at swim-up (determined by fry having <1 mm gap in yolk sac). Ponding generally occurs after the accumulation of 1,650 to 1,750 temperature units. Unfed fry are transferred to start tanks and then to final rearing ponds. Fry are ponded at approximately 1200 fish per pound.

9.1.1.6  Fish Health Maintenance And Monitoring

Eggs are examined daily by hatchery personnel. Prophylactic treatment of eggs for the control of fungus is prescribed by fish-health specialists, and may include treatment with formalin or other accepted fungicides. Non-viable eggs are removed by bulb-syringe or syphon tube and optical egg counters. Adherence to WDFW, Pacific Northwest Fish Health Protection Committee, and IHOT (1995) fish disease-control policies reduces the incidence of diseases in fish produced and released from the Wells Hatchery. Yearling lots are monitored for BKD.

9.1.1.7  Indicate Risk Aversion Measures that will be Applied to Minimize the Likelihood for Adverse Genetic and Ecological Effects to Listed Fish During Incubation

Not applicable. Summer Chinook are not listed.

9.1.2  Rearing

9.1.2.1  Provide Survival Rate Data (Average Program Performance) by Hatchery Life Stage (Fry to Fingerling; Fingerling to Smolt) for the Most Recent Twelve Years (1988-99), or for Years Dependable Data are Available

Tables are provided in Section 9.1.1.

9.1.2.2  Density and Loading Criteria (Goals and Actual Levels)

The rearing conditions at Wells Hatchery are designed on loading densities recommended by Piper et al. (1982; 6 lb/gpm and 0.75 lb/ft³) and Banks (1994; 0.125 lb/ft³/in) (BAMP 1998). The HCP Hatchery Committee may adjust criteria if programs are failing to meet the performance standards and it is determined that such adjustments are likely to significantly improve performance.

9.1.2.3  Fish Rearing Conditions

Fish are reared on a combination of well and river water. Temperature, dissolved oxygen and pond turnover rate are monitored. IHOT standards are followed for: water quality, alarm systems, predator control measures (netting) to provide the necessary security for the cultured stock, loading and density. Settleable solids, unused feed and feces are removed regularly to ensure proper cleanliness of rearing containers. Temperature and dissolved oxygen are monitored and recorded daily during fish rearing.
Subyearling Production Component of Program – emergent fry are ponded in start tanks indoors, then moved to concrete standard raceways (2,250 cubic feet [cf]) in February or March. After marking (~50 fish per pound [fpp]) in April, fish are transferred into large lined earthen pond for final rearing. Subyearlings are volitionally released from adult holding pond in mid-May.

Yearling Production Component of Program – emergent fry are ponded in start tanks indoors, then moved to concrete standard raceways (2,250 cf) in April or May. After marking (~100 fish per pound [fpp]) in June, fish are transferred into large lined earthen pond for rearing through the following April, when fish are volitionally released during mid-April at approximately 10 fpp.

9.1.2.4 Indicate Biweekly or Monthly Fish Growth Information (average program performance), Including Length, Weight, and Condition Factor Data Collected During Rearing, if Available

These data are not collected monthly at the Wells Hatchery.

9.1.2.5 Indicate Monthly Fish Growth Rate and Energy Reserve Data (average program performance), if Available

These data are unavailable at the Wells Hatchery.

9.1.2.6 Indicate Food Type Used, Daily Application Schedule, Feeding Rate Range (e.g., % B.W./day and lbs/gpm inflow), and Estimates of Total Food Conversion Efficiency During Rearing (average program performance)

<table>
<thead>
<tr>
<th>Table 9.3. Food Type Information.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rearing Period</strong></td>
</tr>
<tr>
<td>December-January</td>
</tr>
<tr>
<td>February-March</td>
</tr>
<tr>
<td>April-May</td>
</tr>
<tr>
<td>June-September</td>
</tr>
<tr>
<td>October-April</td>
</tr>
</tbody>
</table>
9.1.2.7 Fish Health Monitoring, Disease Treatment, and Sanitation Procedures

Standard fish-health monitoring will be conducted by a fish-health specialist at frequencies appropriate to the life stage and susceptibility to disease. Significant fish mortality attributable to unknown cause(s) will be sampled appropriately for study (i.e., viral assay, bacterial culture, and histopathology). Fish health maintenance strategies are described in IHOT (1995). Incidence of viral pathogens in summer Chinook broodstock will be determined by sampling fish at spawning in accordance with the Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Populations of particular concern may be sampled at the 100 percent level and may require segregation of eggs/progeny in early incubation or rearing.

Fish are monitored daily by staff during rearing for signs of disease, through observations of feeding behavior and monitoring of daily mortality trends. A fish-health specialist will monitor fish health often as determined necessary. More frequent care will be provided as needed if disease is noted. Hatchery Specialists under the direction of the Fish Health Specialist will provide treatment for disease. Sanitation will consist of raceway cleaning as necessary by brushing, and disinfecting equipment. Fish-health examinations are performed on all summer Chinook production lots throughout the rearing period and pre-release.

All equipment (nets, tanks, boots, etc.) is disinfected with iodophor between different fish/egg lots. Tank trucks are disinfected between the hauling of adult and juvenile fish. Foot baths containing disinfectant are strategically located on the hatchery grounds to prevent spread of pathogens.

The general policy is to bury dead juvenile fish and eggs to minimize the risk of disease transmission to natural fish. Adult summer Chinook carcasses will be buried or disposed of in an approved landfill if individuals have been treated with antibiotics and died within the withdrawal period identified by the FDA. All adults injected with maturation accelerating hormones (such as sGnRHa implants) will be disposed of in an approved landfill, consistent with Investigational New Animal Drug (INAD) requirements.

9.1.2.8 Smolt Development Indices (e.g., Gill ATPase Activity), if Applicable

Degree of smoltification is monitored through monthly collection of data indicating average condition factor (Kfl) of the populations. Gill ATPase levels have been monitored in the past to attempt to indicate degree of smoltification. However, this index has not been found to be a useful tool for determining when to begin releases, due to the delay in obtaining results from sampling, and the finding that ATPase levels do not actually increase until the smolts are actively migrating in the Columbia River (Petersen et al. 1999).

9.1.2.9 Indicate the Use of "Natural" Rearing Methods as Applied in the Program

Currently, natural rearing methods are approached through the transfer of yearling and subyearling Chinook to large, lined, earthen ponds. These ponds provide a more naturalistic setting with low fish densities, exposure to natural food, and natural substrate. Any changes to current rearing approaches must be approved by the HCP HC.
9.1.2.10 Indicate Risk Aversion Measures that will be Applied to Minimize the Likelihood for Adverse Genetic and Ecological Effects to Listed Fish Under Propagation

Not applicable. Summer Chinook are not listed.

10.0 RELEASE

10.1 Describe Fish Release Levels, and Release Practices Applied Through the Hatchery Program

10.1.1 Proposed Fish Release Levels

Table 10.1. Release life stages, numbers, and locations for the Wells Summer Chinook program.

<table>
<thead>
<tr>
<th>Age Class</th>
<th>Maximum Number</th>
<th>Release Date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs</td>
<td>0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Unfed Fry</td>
<td>0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Fry</td>
<td>0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Fingerling</td>
<td>0</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Subyearling</td>
<td>484,000</td>
<td>May</td>
<td>Columbia River</td>
</tr>
<tr>
<td>Yearling</td>
<td>320,000</td>
<td>April</td>
<td>Columbia River</td>
</tr>
</tbody>
</table>

Yearling and subyearling summer Chinook released volitionally directly into the Columbia River from Wells Hatchery.

10.1.2 Specific Location(s) of Proposed Release(s)

Stream, river, or watercourse: Columbia
Release point: Wells Hatchery, RKm 829.0/Mid-Upper Columbia
Major watershed: Columbia
Basin or Region: Columbia

Fish are released on station from the Wells Hatchery to the Columbia River at RKm 829.0, located immediately downstream of Wells Dam.
10.1.3  Actual Numbers and Sizes of Fish Released by Age Class Through the Program

Table 10.2.  Wells Hatchery summer Chinook releases, 1992-2010.

<table>
<thead>
<tr>
<th>Brood</th>
<th>Wells summer Chinook salmon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subyearling</td>
</tr>
<tr>
<td>2010^i</td>
<td>442,821</td>
</tr>
<tr>
<td>2009</td>
<td>471,286</td>
</tr>
<tr>
<td>2008</td>
<td>427,131</td>
</tr>
<tr>
<td>2007</td>
<td>402,527</td>
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<tr>
<td>2006</td>
<td>396,538</td>
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<tr>
<td>2005</td>
<td>430,203</td>
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<td>2004</td>
<td>471,123</td>
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<td>2003</td>
<td>425,271</td>
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<td>2002</td>
<td>473,100</td>
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<td>2001</td>
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<tr>
<td>2000</td>
<td>498,500</td>
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<tr>
<td>1999</td>
<td>363,600</td>
</tr>
<tr>
<td>1998</td>
<td>370,617</td>
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<tr>
<td>1997</td>
<td>541,923</td>
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<td>1996</td>
<td>473,000</td>
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<td>1995</td>
<td>408,000</td>
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<td>1994</td>
<td>450,935</td>
</tr>
<tr>
<td>1993</td>
<td>187,382</td>
</tr>
<tr>
<td>1992</td>
<td>-</td>
</tr>
</tbody>
</table>

^1 Yearling release pending

10.1.4  Actual Dates of Release and Description of Release Protocols

Volitional release: yearlings in April (~14th) and subyearlings in May (~15th). Yearlings are forced out by May 15, and subyearlings are forced out by the end of May. The vast majority of fish have volitionally released prior to force-out. Release dates coincide with natural migration timing.

10.1.5  Fish Transportation Procedures, if Applicable

Not applicable. No transportation used.

10.1.6  Acclimation Procedures (methods applied and length of time)

Fish have been term reared at the facility on river water. All fish are acclimated and volitionally released from Wells Hatchery into the Columbia River.
10.1.7 Marks Applied, and Proportions of the Total Hatchery Population Marked, to Identify Hatchery Adults

One hundred percent adipose-fin clipped and 100% CWT. Additional marking will be applied as needed for evaluation purposes.

10.1.8 Disposition Plans for Fish Identified at the Time of Release as Surplus to Programmed or Approved Levels

Broodstock and egg collections are designed to minimize the potential for releases of surplus fish (see Section 9.1.2). The HCP HC will monitor survival at successive life stages to identify the probability of surplus fish at release, and will determine corrective measures (such as culling or transferring surpluses to other programs) at those life stages as necessary. Thus, surplus smolts are not expected.

10.1.9 Fish Health Certification Procedures Applied Pre-release

Fish health and disease condition are continuously monitored in compliance with the requirements of the “Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State” (Co-Managers 1998), requirements of the current Section 10 ESA permit (No. 1347), and guidelines of IHOT (1995). Summer Chinook are monitored daily by staff during rearing for signs of disease, through observations of feeding behavior, and monitoring of daily mortality trends. A fish health specialist monitors fish health at least monthly; these inspections must adhere to the disease prevention and control guidelines established by the Pacific Northwest Fish Health Protection Committee. More frequent care will be provided as needed if disease is noted. Prior to release, the population health and condition is established by the Area Fish Health Specialist. This is commonly done 1-3 weeks pre-release, and up to 6 weeks pre-release on systems with pathogen free water and little or no history of disease.

10.1.10 Emergency Release Procedures in Response to Flooding or Water System Failure

Emergency releases shall be allowed in the event of flooding, water loss to raceways, or vandalism that necessitates early release of summer Chinook to prevent catastrophic mortality. Any emergency releases made by the hatchery operators will be reported immediately to the NMFS Salmon Recovery Division in Portland, OR.

In the event of a water-system failure, screens will be pulled to allow fish to exit the ponds, or in some cases they will be transferred into other rearing vessels to prevent an emergency release. Upon permission, fish would be force-released into the Columbia River by pulling the screens/outlets of rearing units. Outlet screens/stop logs of the ponds would be pulled, and fish would be forced out, or allowed to volitionally move into the Columbia. This would only occur if the program were in jeopardy. WDFW also has emergency response procedures for providing back-up pumps, transport trucks, etc. in cases of emergency. In cases of severe flooding the screens will not be pulled because flood waters rise to the point where they breach the ponds. Every effort will be made to avoid pre-programmed releases including transfer to alternate
facilities. Emergency releases, if necessary and authorized, would be managed by removal of outlet screens and pull sumps of the rearing units. If possible, staff would set up portable pumps to use river water to flush the fish.

10.1.11 **Indicate Risk Aversion Measures that will be Applied to Minimize the Likelihood for Adverse Genetic and Ecological Effects to Listed Fish Resulting from Fish Releases**

Measures have been applied to ensure that artificially propagated summer Chinook salmon juveniles that are released are ready to actively migrate to the ocean with minimal delay. To meet this condition, fish must be released at a uniform size and state of smoltification that promotes seaward migration without delay. Subyearlings are expected to display a more varied migratory behavior due to their intrinsic life history plasticity. Variance from this smolts-only release requirement shall only be allowed in the event of an emergency, such as flooding, water loss to raceways, or vandalism that necessitates early release. Any emergency releases made by the action agencies shall be reported immediately to the NMFS Salmon Recovery Division. The rearing and release strategies are designed to limit ecological interactions between hatchery and naturally produced fish. Fish are reared until smoltification has occurred within nearly the entire population, which reduces residence time in streams following release (Bugert 1998). To indicate when fish should be allowed to volitionally migrate, physiological measures of the degree of smoltification within the hatchery population, including allowable fork length coefficient of variation maximums (CV less than 10%) and average condition factor at release targets (0.9 - 1.0) will be used.

Through these practices, smolts will migrate seaward without delay, minimizing interactions with listed wild spring Chinook and steelhead juveniles and smolts that rear in and/or migrate through freshwater and estuarine areas. In addition, smolt releases will continue to be timed with water budget releases from upstream dams, to further accelerate seaward migration of released hatchery fish and reduce the duration of any interactions with wild fish. On-station rearing of summer Chinook on parent river water in the upper Columbia region will also contribute to the smoltification process leading to reduced hatchery fish residence time in the rivers and mainstem migration corridors.

All propagated summer Chinook juveniles shall be externally and internally marked (i.e., CWT and adipose fin clipped) prior to release.

Fish will be monitored daily by staff during rearing for signs of disease, through observations of feeding behavior and monitoring of daily mortality trends. A fish health specialist will monitor fish health at least monthly. More frequent care will be provided as needed if disease is detected. Prior to release, population health and condition is established by the Area Fish Health Specialist. Adherence to WDFW, Pacific Northwest Fish Health Protection Committee, and IHOT (1995) fish disease control policies will reduce the incidence of diseases in hatchery fish produced and released. Fish health management programs affecting all stocks, and fish health activities specific for each complex, are detailed in Appendix II, under “Objective 4: Maximize survival at all life stages using disease control and disease prevention techniques. Prevent introduction, spread, or amplification of fish pathogens.”
MONITORING AND EVALUATION OF PERFORMANCE INDICATORS

Monitoring and Evaluation of “Performance Indicators” Presented in Section 1.10

The HCP HC has developed a rigorous monitoring plan (M&E Plan) for the Wells Hatchery summer Chinook program (Hillman et al., 2013), attached as Appendix B. Douglas PUD funds an M&E program based upon that M&E Plan. Implementation of the M&E Plan is guided by an annual M&E Implementation Plan ([Murdoch and Snow 2012]), attached as Appendix C) prepared by Douglas PUD’s M&E contractor (currently WDFW) and approved by the HCP Hatchery Committee. The M&E program is subject to review by the HCP Hatchery Committee every five years (or as needed), and it is within the purview of the HCP HC to modify the M&E Plan (and thus, the M&E program) at any time (adaptive management).

The monitoring and evaluation program is consistent with the draft monitoring and evaluation plan prepared by NMFS for the Recovery Plan (see Appendix P to the Recovery Plan; UCSRB 2007) and the Ad Hoc Supplementation Monitoring and Evaluation Workgroup recommendations (Galbreath et al. 2008).

Describe Plans and Methods Proposed to Collect Data Necessary to Respond to Each “Performance Indicator” Identified for the Program

The M&E Plan (Appendix B) thoroughly describe the program objectives, their respective hypotheses, measured variables, derived metrics, and analyses.

Indicate Whether Funding, Staffing, and Other Support Logistics are Available or Committed to Allow Implementation of the Monitoring and Evaluation Program

Douglas PUD funds the M&E activities for this program. WDFW, as a contractor to Douglas PUD and co-holder of the permit, currently provides the personnel and equipment for conducting these activities. Copies of the Annual Report on M&E activities are routinely and regularly provided to NMFS through its representative on the Wells HCP HC.
11.2 **Indicate Risk Aversion Measures that will be Applied to Minimize the Likelihood for Adverse Genetic and Ecological Effects to Listed Fish Resulting from Monitoring and Evaluation Activities**

Trapping for broodstock at Wells Dam is active (personnel on site at all times) and is selective for target fish. The trap in the Wells Hatchery volunteer channel will be checked a minimum of once every 24 hours, and more often as conditions require. Non-target fish will be released unharmed.

12.0 **RESEARCH**

Other than what data collection and analysis are encompassed within the M&E activities described in Section 11 and Appendices A and B, no specific research projects are ongoing or proposed in association with the Wells Hatchery summer Chinook program. Any unanticipated, future research that may be associated with this program must be approved by the HCP Hatchery Committees.
13.0 ATTACHMENTS AND CITATIONS


Hillman, T., M. Miller, J. Murauskus, L. Keller, T. Miller, M. Tonseth, M. Hughes, and A.


NMFS. 2003a. National Marine Fisheries Service Endangered Species Act (ESA) Section 7 Consultation Biological Opinion and Magnuson-Stevens Act Chinook Salmon Essential Fish Habitat Consultation for Proposed Issuance of a Section 10 Incidental Take Permit (1347) to the Washington Department of Fish and Wildlife (WDFW), the Public Utility District No. 1 of Chelan County, and the Public Utility District No. 1 of Douglas County. Log Number: 1999/01883.


NMFS. 2003c. National Marine Fisheries Service Endangered Species Act (ESA) Section 7 Consultation Biological Opinion and Magnuson-Stevens Act Steelhead Essential Fish Habitat Consultation for Proposed Issuance of a Section 10 Incidental Take Permit (1395) to the Washington Department of Fish and Wildlife (WDFW), the Public Utility District No. 1 of Chelan County, and the Public Utility District No. 1 of Douglas County. Log Number: 2002/000981.


14.0 CERTIFICATION LANGUAGE AND SIGNATURE OF RESPONSIBLE PARTY

"I hereby certify that the information provided is complete, true and correct to the best of my knowledge and belief. I understand that the information provided in this HGMP is submitted for the purpose of receiving limits from take prohibitions specified under the Endangered Species Act of 1973 (16 U.S.C.1531-1543) and regulations promulgated thereafter for the proposed hatchery program, and that any false statement may subject me to the criminal penalties of 18 U.S.C. 1001. or penalties provided under the Endangered Species Act of 1973."

Name, Title, and Signature of Applicant:

Name: Kelly Cunningham                Name: William C. Dobbins
Title: Deputy Assistant Director      Title: General Manager
Signature:                           Signature: W.C. Dobbs
Date: 6/11/13                        Date: June 12, 2013
Table 1. Estimated listed UCR Spring Chinook take levels of by hatchery activity.

<table>
<thead>
<tr>
<th>Listed species affected: UCR Spring Chinook</th>
<th>ESU/Population: Methow, Entiat, Wenatchee Populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity: Implement Hatchery Program</td>
<td></td>
</tr>
<tr>
<td>Location of hatchery activity: Wells Hatchery, Wells Dam</td>
<td>Dates of activity: Broodstock collection: July-September; Juvenile release: April and May</td>
</tr>
<tr>
<td>Hatchery program operator: Currently WDFW</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Take</th>
<th>Annual Take of Listed Fish By Life Stage (Number of Fish)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observe or harass</td>
<td>a)</td>
</tr>
<tr>
<td>Collect for transport</td>
<td>b)</td>
</tr>
<tr>
<td>Capture, handle, and release</td>
<td>c)</td>
</tr>
<tr>
<td>Capture, handle, tag/mark/tissue sample, and release</td>
<td>d)</td>
</tr>
<tr>
<td>Removal (e.g. broodstock)</td>
<td>e)</td>
</tr>
<tr>
<td>Intentional lethal take</td>
<td>f)</td>
</tr>
<tr>
<td>Unintentional lethal take</td>
<td>g)</td>
</tr>
<tr>
<td>Other Take (specify)</td>
<td>h)</td>
</tr>
<tr>
<td></td>
<td>Egg/Fry</td>
</tr>
<tr>
<td>Observe or harass</td>
<td>a)</td>
</tr>
<tr>
<td>Collect for transport</td>
<td>b)</td>
</tr>
<tr>
<td>Capture, handle, and release</td>
<td>c)</td>
</tr>
<tr>
<td>Capture, handle, tag/mark/tissue sample, and release</td>
<td>d)</td>
</tr>
<tr>
<td>Removal (e.g. broodstock)</td>
<td>e)</td>
</tr>
<tr>
<td>Intentional lethal take</td>
<td>f)</td>
</tr>
<tr>
<td>Unintentional lethal take</td>
<td>g)</td>
</tr>
<tr>
<td>Other Take (specify)</td>
<td>h)</td>
</tr>
</tbody>
</table>

a. Delay of listed fish at ladder traps.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release. N.A.
c. Take associated with trapping operations where listed fish are captured, handled and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release.
e. Listed fish removed from the wild and collected for use as broodstock. N.A.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock. N.A.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to release into the wild.
h. Other takes not identified above as a category. N.A.
Table 2. Estimated listed UCR Summer Steelhead take levels of by hatchery activity.

| Listed species affected: UCR Summer Steelhead | ESU/Population: Methow, Okanogan, Entiat, Wenatchee Populations |
| Activity: Implement Hatchery Program |
| Location of hatchery activity: Wells Hatchery, Wells Dam | Dates of activity: Broodstock collection: July-September; Juvenile release: April and May | Hatchery program operator: Currently WDFW |

<table>
<thead>
<tr>
<th>Type of Take</th>
<th>Annual Take of Listed Fish By Life Stage <em>(Number of Fish)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Egg/Fry</td>
</tr>
<tr>
<td>Observe or harass</td>
<td>a)</td>
</tr>
<tr>
<td>Collect for transport</td>
<td>b)</td>
</tr>
<tr>
<td>Capture, handle, and release</td>
<td>c)</td>
</tr>
<tr>
<td>Capture, handle, tag/mark/tissue sample, and release</td>
<td>d)</td>
</tr>
<tr>
<td>Removal (e.g. broodstock)</td>
<td>e)</td>
</tr>
<tr>
<td>Intentional lethal take</td>
<td>f)</td>
</tr>
<tr>
<td>Unintentional lethal take</td>
<td>g)</td>
</tr>
<tr>
<td>Other Take (specify)</td>
<td>h)</td>
</tr>
</tbody>
</table>

a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at trapping locations.
b. Take associated with weir or trapping operations where listed fish are captured and transported for release. N.A.
c. Take associated with trapping operations where listed fish are captured, handled and released upstream or downstream.
d. Take occurring due to tagging and/or bio-sampling of fish collected through trapping operations prior to upstream or downstream release, or through carcass recovery programs.
e. Listed fish removed from the wild and collected for use as broodstock. N.A.
f. Intentional mortality of listed fish, usually as a result of spawning as broodstock. N.A.
g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to release into the wild.
h. Other takes not identified above as a category. N.A.
Table 3. Estimated listed UCR Bull Trout take levels of by hatchery activity.

| Listed species affected: UCR Bull Trout | DPS/Population: Methow, Okanogan, Entiat, Wenatchee Populations |
| Location of hatchery activity: Wells Hatchery, Wells Dam | Dates of activity: Broodstock collection: July-September; Juvenile release: April and May |
| Hatchery program operator: Currently WDFW |

Please see the Wells Hydroelectric Project Bull Trout Biological Opinion for bull trout take levels:

APPENDIX A

WELLS HYDROELECTRIC PROJECT ANADROMOUS FISH AGREEMENT AND HABITAT CONSERVATION PLAN
May 23, 2002

Mr. Robert D. Lohn
Regional Administrator
National Marine Fisheries Service
Northwest Region
7600 Sand Point Way NE
Seattle, Washington 98115-0070

Re: Amended, Application for Individual Incidental Take Permit
Wells Hydroelectric Project (FERC No. 2149)

Dear Mr. Lohn:

On July 31, 1998, the Public Utility District No. 1 of Douglas County, Washington (Douglas), pursuant to 16 USC § 1539(1)(B) and 50 CFR § 222.22(b) (2001), submitted to the National Marine Fisheries Service (NMFS) an application for issuance of an incidental take permit for the Wells Hydroelectric Project. The permit application was based upon the 1998 version of the Wells Anadromous Fish Agreement and Habitat Conservation Plan (1998 Wells HCP).

Upon receiving the permit application and pursuant to 42 USC § 4322(2)(c), NMFS initiated a National Environmental Policy Act (NEPA) review of the proposed 1998 Wells HCP. The NEPA review process required the development of a Draft Environmental Impact Statement (DEIS). On December 29, 2000, notice of the DEIS was published in the Federal Register for the proposed Wells, Rocky Reach and Rock Island HCPs. Comments were accepted through March 2001.

Comments on the DEIS were compiled and reviewed by NMFS staff. Based upon the comments received, the parties involved in the negotiation of the 1998 Wells HCP decided that additional discussions were required to resolve issues raised by the commentators prior to the issuance of a Final Environmental Impact Statement.
These discussions were initiated in April 2001 and have only recently concluded to the satisfaction of all interested parties. As a result, we are pleased to submit to NMFS a signed version of the Wells HCP (2002 Wells HCP). The 2002 Wells HCP does not change the fundamentals of the 1998 Wells HCP, but merely clarifies concepts. The provisions related to this Agreement shall become effective only after NMFS issues the requested permit, and the Federal Energy Regulatory Commission issues the orders contemplated by the 2002 Wells HCP.

Based upon the clarifications described above, Douglas hereby amends its incidental take permit application to:

(1) replace Exhibit 1, the proposed “1998 Wells HCP”, with the “2002 Wells HCP;

(2) remove Exhibit 1-A, 1-B, and 1-C and;

(3) rename Exhibit 1-D as Exhibit 2.

The application, including the above-described changes, should now read:

Exhibit 1. Anadromous Fish Agreement and Habitat Conservation Plan, The Wells Hydroelectric Project, FERC License No. 2149, March 26, 2002.

Exhibit 2. Wells Hydroelectric Project Habitat Conservation Plan.

Should a conflict arise between Exhibit 1 and any of the remaining Exhibits, Supporting Documents or Appendices to this amended Permit Application, the language contained within Exhibit 1 shall control.

Copies of this letter and its enclosures are being sent to (1) the Assistant Administrator for Fisheries, Silver Springs, Maryland, pursuant to 50 CFR § 222.307(b) (2001) and 50 CFR § 222.102 (2001); and (2) the parties participating in the development of the signed 2002 Wells HCP.

---

1 Exhibits 1 – A, 1 – B and 1 – C are now referenced separately as Supporting Documents D, A, and B, respectively and are referenced exclusively from within the 2002 Wells HCP (Exhibit 1).
Letter to Mr. Robert D. Lohn
May 23, 2002
Page 3

If you have any questions pertaining to this letter or if you require additional information, please feel free to contact me at (509) 884-7191 Ext. 2285, rclubb@dcpud.org or Shane Bickford Ext. 2208, sbickford@dcpud.org. Alternatively, please feel free to contact the District’s council in this matter, Stan Bastian, at (509) 662-3685, stanB@IDSALaw.com.

Sincerely,

[Signature]

Robert W. Clubb, PhD
Chief of Environmental and Regulatory Services

Enclosures
cc: See attached Service List
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Keith Brooks, Esq.
Federal Energy Regulatory Commission
8888 First Street NE, Room 10P-O
Washington, D.C. 20426
EXHIBIT NO. 1

Anadromous Fish Agreement and
Habitat Conservation Plan
The Wells Hydroelectric Project
FERC License No. 2149

March 26, 2002
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Anadromous Fish Agreement and Habitat Conservation Plan
Wells Hydroelectric Project, FERC License No. 2149

THIS AGREEMENT for the Wells Hydroelectric Project (Project) is entered into between the Public Utility District No. 1 of Douglas County, Washington, (District) a Washington municipal corporation; the United States Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the Washington Department of Fish and Wildlife (WDFW), the Confederated Tribes of the Colville Reservation (Colville), the Confederated Tribes and Bands of the Yakama Indian Nation (Yakama), the Confederated Tribes of the Umatilla Indian Reservation (Umatilla) (collectively, the Joint Fisheries Parties or the JFP); and American Rivers, Inc., (American Rivers) a Washington D.C., nonprofit corporation (the JFP and American Rivers, are referred to as the Fisheries Parties (FP); and the Power Purchasers which shall be represented through a single non-voting representative whom they will designate from time to time. All entities, who have executed this agreement, are collectively referred to as the Parties.

INTRODUCTION

A. The site of the Project is habitat for Plan Species. Prior to this Agreement the needs of the Plan Species and their habitat have been addressed through litigation and agreement. This Agreement is intended to constitute a comprehensive and long-term adaptive management plan for Plan Species and their habitat as affected by the Project.

B. The objective of this Agreement is to achieve No Net Impact (NNI) for each Plan Species affected by the Project on the schedule set out herein and to maintain the same for the duration of the Agreement. NNI consists of two components: (1) 91% Combined Adult and Juvenile Project Survival achieved by project improvement Measures implemented within the geographic area of the Project (2) 9% compensation for Unavoidable Project Mortality provided through hatchery and tributary programs, with 7% compensation provided through hatchery programs and 2% compensation provided through tributary programs. The Parties intend these actions to contribute to the rebuilding of tributary habitat production capacity and basic productivity and numerical abundance of Plan Species.

C. The District will receive a Permit for Permit Species upon this Agreement becoming effective. If the District carries out its responsibilities for fish protection and mitigation Measures set out in this Agreement, and provide the necessary monitoring and evaluation, all according to the time...
frames set out for each Measure, the Permit shall continue for the full term of this Agreement subject to Section 2 (Termination) and Section 10 (Endangered Species Act Compliance). The Parties shall take the actions set out in this Agreement in support of the District before the Federal Energy Regulatory Commission (FERC) and in other forums.

D. Capitalized terms used in this Agreement are defined in Section 13 (Definitions).

NOW, THEREFORE, IN CONSIDERATION of the mutual promises and conditions set forth herein, the Parties agree as follows:

SECTION 1
TERM OF AGREEMENT

1.1 Term. Unless terminated early according to Section 2 (Termination), this Agreement shall become effective on the date this Agreement is approved by FERC and shall remain in full force and effect for a period of fifty (50) years from that date. From the date this Agreement becomes effective, it shall prospectively supersede the Wells Settlement Agreement dated October 1, 1990.

SECTION 2
TERMINATION

2.1 Automatic Termination Events. This Agreement shall terminate automatically: (1) at the end of the term of the Agreement as set forth in Section 1 (Term of Agreement), (2) in the event the FERC issues the District a non-power license for the Project, (3) in the event the FERC orders removal of the Project, (4) in the event the FERC orders drawdown of the Project or (5) the District withdraws from this Agreement based on sub-Section 2.2 (Elective Withdrawal Events). The District’s obligations under this Agreement shall terminate in the event its FERC license is terminated or transferred to another entity. The Parties agree that the terms of this Agreement shall be binding on their respective successors and assigns.

2.2 Elective Withdrawal Events.  
2.2.1 Enough Already.  
2.2.1.1 A Party may withdraw from this Agreement when at least twenty (20) years has elapsed from March 1, 1998, subject to the following conditions: (1) No Net Impact (NNI) has not been achieved or has been achieved but has not been maintained, or (2) the Project has achieved and maintained NNI but the Plan Species are not rebuilding and the Project is a significant factor in the failure to rebuild.
2.2.1.2 If NMFS and the District are in agreement as to specific Measures to remedy the District’s failure to achieve or maintain NNI and the District promptly implements agreed Measures that are applicable to the District, NMFS will refrain from suspending or revoking the Permit. In the event that NNI has not been achieved or has been achieved but has not been maintained by March 1, 2018, but the District is otherwise performing all obligations assigned to it in the Permit, and is otherwise in full compliance with all terms and conditions of this Agreement and the Permit, NMFS and USFWS will not exercise their right to withdraw from this Agreement or revoke the Permit unless such withdrawal is explicitly to seek drawdown, dam removal, and/or non-power operations, or actions for achievement of NNI. Should the District, NMFS, and USFWS agree under these circumstances, such actions may be pursued without withdrawing from the Agreement or suspension or revocation of the Permit.

2.2.2 Non-Compliance. A Party may elect at any time to withdraw from the Agreement based on non-compliance of another Party with the provisions of the Agreement, but only subject to the following procedures: (1) a Party asserts that another Party is not complying with the terms of the Agreement, (2) the Party documents and presents evidence supporting assertion of non-compliance in writing (3) the issue of non-compliance is taken to Dispute Resolution, Section 11 (Dispute Resolution), unless waived. Following Dispute Resolution, a Party choosing to withdraw, shall provide all other Parties with notice of withdrawal. The notice shall be in writing and either served in person or provided by U. S. Mail return receipt requested. The right to withdraw shall be waived if not exercised within 60 Days of Dispute Resolution being completed. Sub-Section 2.2.6 (Withdrawal of Another Party) applies to a Party’s receipt of notice provided for in this sub-Section.

2.2.3 Governmental Action. A Party may elect to withdraw from this Agreement, pursuant to 9.3.2, in the event that an entity with regulatory authority takes action that (1) is detrimental to the achievement of the obligations set forth in this Agreement and (2) that materially alters or is contrary to one or more terms set forth in this Agreement.

2.2.4 Impossibility. A Party may elect to withdraw from the Agreement in the event the Parties agree in writing that the obligations imposed by this Agreement are impossible to achieve.
2.2.5 Revocation of Permit. A Party may elect to withdraw from the Agreement if the NMFS revokes the Permit.

2.2.6 Withdrawal of Another Party. Upon receipt of a Party’s notice of intent to withdraw, any other Party shall have 120 Days from the date of such notice to provide notice to all Parties of its intent to withdraw from this Agreement, or this right to withdraw shall be waived.

2.3 Conditions Precedent to Withdrawal. Two conditions must be satisfied before a Party can withdraw from the Agreement pursuant to sub-Section 2.2.3 (Governmental Action), 2.2.4 (Impossibility), sub-Section 2.2.5 (Revocation of Permit) or sub-Section 2.2.6 (Withdrawal of Another Party). First, the Party desiring to withdraw from the Agreement shall provide written notice to all other Parties of its intent to withdraw. The notice shall be in writing and either served in person or provided by U. S. Mail return receipt requested. The notice shall state the date upon which the Party’s withdrawal shall become effective. The date upon which the Party’s withdrawal becomes effective shall be no less than sixty (60) Days from the date the notice was provided to all other Parties. Second, prior to the date upon which the Party’s withdrawal becomes effective the withdrawing Party (Parties) must make itself (themselves) available for at least one policy meeting to allow remaining Parties to attempt to persuade the withdrawing Party (Parties) not to withdraw. The policy meeting must take place within the sixty (60) Day period or it is waived.

2.4 Effect of Withdrawal. Except as set forth in sub-Section 2.5 (Effect of Termination), sub-Sections 9.4.1 and 9.4.3, and sub-Sections 10.5 (Permit Suspension, Revocation and Re-Instatement) and 10.6 (Early Termination Mitigation), in the event a Party withdraws from this Agreement, this Agreement places no constraints on the withdrawing Party, shall not thereafter be binding on the withdrawing Party, and the withdrawing Party may exercise all rights and remedies that the Party would otherwise have.

2.5 Effect of Termination. Except as set forth in sub-Section 7.3.7.6 (Account Status upon Termination), sub-Sections 9.4.1 and 9.4.3 and sub-Sections 10.5 (Permit Suspension, Revocation and Re-Instatement) and 10.6 (Early Termination Mitigation), upon expiration of this Agreement, or in the event this Agreement is terminated, voided or determined for any reason to be unenforceable before the end of its term, then: (1) the District shall continue to implement the last agreed to Measures until the FERC orders otherwise, and (2) the Parties are not restrained in any manner from advocating to the FERC Measures to replace the Agreement.
SECTION 3
SURVIVAL STANDARDS AND ALLOCATION
OF RESPONSIBILITY FOR NO NET IMPACT

3.1 No Net Impact (NNI) shall be achieved on the schedule set out herein, and maintained for the duration of the Agreement for each Plan Species affected by the Project. NNI consists of two components: (1) 91% Combined Adult and Juvenile Project Survival achieved by project improvement Measures implemented within the geographic area of the Project, (2) 9% compensation for Unavoidable Project Mortality provided through hatchery and tributary programs, with 7% compensation provided through hatchery programs and 2% compensation provided through tributary programs. Measures and Survival Standards, as provided in Section 4 (Passage Survival Plan), Section 7 (Tributary Conservation Plan) and Section 8 (Hatchery Compensation Plan), shall be evaluated as provided in sub-Sections 6.9 (Progress Reports) and achieved no later than March 2013). The inability to measure a standard due to limitations of technology shall not be construed as a success or a failure to achieve NNI as further explained in sub-Section 4.1.1 (91% Combined Adult and Juvenile Survival) and sub-Section 4.1.2 (93% Juvenile Project Survival and 95% Juvenile Dam Passage Survival).

Based upon the best available information the District will achieve NNI within a few years time, well before the 2013 date. The District has achieved the 93% Juvenile Project Survival goal for yearling chinook and steelhead (See sub-Section 4.2.1 Phase I (1998-2002)) and Parties believe that the calculated Juvenile Dam Passage Survival for sockeye and sub-yearling chinook is probably greater than 95%. Adult survival cannot be conclusively measured at this time, as indicated in sub-Section 4.1.1 (91% Combined Adult and Juvenile Survival) and 4.1.3 (Adult Survival Assumptions). The Plan Species Account will be established upon FERC approval and will be used to fully compensate for adult mortality until an adult survival study can be conducted. The District has provided or is in the process of providing the 7% hatchery commitments or equivalent (in the case of sockeye). Achievement of the NNI goal by 2013 does not affect or diminish the provisions of sub-Section 2.2.1 (Enough Already) and sub-Section 9.5 (Re-Licensing).

3.2 To ensure NNI is achieved and maintained, the Coordinating Committee shall: (1) oversee monitoring and evaluation, and (2) periodically adjust the Measures to address actual project survival and Unavoidable Project Mortality as provided herein; provided that no more than 9% Unavoidable Project Mortality shall be made up through hatchery and tributary compensation without concurrence of the Coordinating Committee. Initially, adult survival estimates...
will be used to adjust the Plan Species Account contribution and Juvenile Project Survival estimates will be used to adjust hatchery based compensation programs (See Section 7: Example 1 and See Section 8: Example 2).

However, should adult survival rates fall below 98%, but the Combined Adult and Juvenile survival rate be maintained above 91%, additional hatchery compensation for that portion of adult losses that exceeds 2%, toward a maximum contribution of 7% hatchery funding and 2% tributary funding, would be utilized to satisfy the NNI compensation requirements for each Plan Species. Hatchery compensation shall not exceed 7% and tributary funding shall not exceed 2% unless agreed to by the Coordinating Committee.

3.3 The District shall be responsible for achieving the pertinent survival standard as provided in Section 3 (Survival Standards and Allocation of Responsibility for No Net Impact) and 4 (Passage Survival Plan) for each Plan Species affected by the Project through project improvement Measures (including adult, juvenile, and reservoir Measures). The District shall also be responsible for (1) funding the Tributary Conservation Plan as provided in Section 7; (2) providing the capacity and funding for the 7% Hatchery Compensation Plan as provided in Section 8; and (3) making capacity and funding adjustments to the Hatchery Compensation Plan to reflect and fully compensate for future increases in the run size of each Plan Species as provided in sub-Section 8.4.5 (Adjustment of Hatchery Compensation – Population Dynamics) and further adjustments to the Hatchery Compensation Plan to reflect the results of survival studies as provided in Section 8.4.4 (Adjustment of Hatchery Compensation – Survival Studies). If the District is unable to achieve the pertinent survival standard, then the District shall consult with the Parties through the Coordinating Committee to jointly seek a solution. If a solution cannot be identified to achieve the survival standards identified herein, any Party may take action under sub-Section 2.2.4 (Impossibility), or other provisions of this Agreement.

3.4 The Tributary Committee and Hatchery Committee shall develop plans and programs, which must include evaluation procedures, necessary to implement the Tributary Conservation Plan and the Hatchery Compensation Plan, respectively to compensate for Unavoidable Project Mortality. If Unavoidable Project Mortality is not compensated for through the Hatchery Compensation Plan, the Hatchery Committee may examine additional hatchery improvements to meet the Unavoidable Project Mortality hatchery obligation. If the Hatchery and Tributary Committees are unable to develop plans and programs to fully implement the Hatchery Compensation Plan and Tributary Conservation Plan, respectively, to meet compensation levels necessary to meet
NNI, then the respective committees may consult with the Coordinating Committee to jointly seek a solution.

3.5 Implementation of Measures to meet NNI shall follow the time frames set out in the Passage Survival Plan, the Tributary Conservation Plan and the Hatchery Compensation Plan. Where a deadline is not specified, implementation of Measures shall occur as soon as is reasonably possible.

SECTION 4
PASSAGE SURVIVAL PLAN

4.1 Survival Standards.

4.1.1 91% Combined Adult and Juvenile Survival. The District shall achieve and maintain 91% Combined Adult and Juvenile Project Survival, as required in sub-Section 3.3, which means that 91% of each Plan Species, juvenile and adult combined, survive Project effects. As of 2002, the Parties agree that adult fish survival cannot be conclusively measured for each Plan Species. Until technology is available to accurately determine Project effects, the District will implement the adult Measures as identified in sub-Section 4.4 (Adult Passage Plan). Given the present inability to differentiate between the sources of adult mortality, initial compliance with the Combined Adult and Juvenile Survival standard will be based upon the measurement of juvenile survival as provided in Section 4.1.2, (93% Juvenile Project Survival and 95% Juvenile Dam Passage Survival) below. It is anticipated that the District shall implement the measurement of adult survival at some time in the future should adult survival study methodologies and study plans be agreed to by the Coordinating Committee. Mitigation Measures will be adjusted at that time, if necessary, to address the new information.

4.1.2 93% Juvenile Project Survival and 95% Juvenile Dam Passage Survival. Limitations associated with the best available technology have required the development of three standards for assessing juvenile fish survival at the project. In order of priority they are: 1) Measured Juvenile Project Survival; 2) Measured Juvenile Dam Passage Survival; and 3) Calculated Juvenile Dam Passage Survival. The survival of each Plan Species shall be determined by using one of these standards, with subsequent evaluations implemented as appropriate, per the following guidelines. If the Combined Adult and Juvenile Project Survival cannot be measured, then Juvenile Project Survival shall be measured as the next best alternative until measurement is possible (See Section 13, “Juvenile Project Survival”).

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If Juvenile Project Survival for each Plan Species is measured to be greater than or equal to 93%, then the District will be assigned to Phase III (Standards Achieved). If Juvenile Project Survival is measured at less than 93% but greater than or equal to 91%, then the District will be assigned to Phase III (Provisional Review). If Juvenile Project Survival is measured at less than 91%, then the District will be assigned to Phase II (Interim Tools) (See Section 14, Figure 1. Wells HCP Survival Standard Decision Matrix).

Wells HCP Survival Standard Decision Matrix. The decision making process for implementation of the survival standards explained in Sections 4.1 (Survival Standards) and 4.2 (Phased Implementation Plans) is graphically depicted in Figure 1 below and Section 14 (Figures).

Figure 1. Wells HCP Survival Standard Decision Matrix
If Juvenile Project Survival cannot be measured, then Juvenile Dam Passage Survival shall be measured as the next best alternative until project measurement is possible (See Section 13, “Juvenile Dam Passage Survival”). The Juvenile Dam Passage Survival Standard is 95%.

For some Plan Species such as sockeye and subyearling chinook where measurement of Juvenile Project Survival and Juvenile Dam Passage Survival is not yet possible, the Juvenile Dam Passage Survival Standard will be calculated based on the best available information (including the proportion of fish utilizing specific passage routes and the use of off-site information), as determined by the Coordinating Committee. This calculation will consider the same elements as measured Juvenile Dam Passage Survival, except that off-site information may be used where site-specific information is lacking.

4.1.3 Adult Survival Assumptions. As of 2002, the Parties agree that adult fish survival cannot be conclusively measured for each Plan Species. Based on regional information, the survival of adult Plan Species is estimated to be 98-100%. Until, the Coordinating Committee approves and the District implements adult survival studies, the District will implement the adult passage Measures identified in sub-Section 4.4 (Adult Passage Plan) and provide the Tributary Conservation Plan account specified in Section 7 (Tributary Conservation Plan).

4.1.4 Methodologies. The survival standards contained within Section 4 (Passage Survival Plan) will be measured using the best available technology and study designs approved by the Coordinating Committee. Current methodologies are summarized in Supporting Document C. These methodologies are not exclusive, and may be updated based on new information or techniques. Juvenile Plan Species survival shall be measured at a ninety-five percent (95%) confidence level, with a standard error of the estimate that shall be not more than plus or minus 2.5% (i.e. 5% error). Results from a study meeting this precision level will automatically be included in the three-year average, unless the study has violated critical model assumptions or has been determined to be invalid by the Coordinating Committee. If a study meet all of the testing protocol and model assumptions and provided that the standard error around the point estimate does not exceed plus or minus 3.5%, then the Coordinating Committee, following unanimous approval, may utilize this information in the calculation of the three-year average. Point estimates of survival measured from the three years of valid studies shall be averaged (arithmetic) to compare against the pertinent Plan Species Survival Standard. The use of survival studies with standard errors between 2.5% and 3.5% shall not be subject to Dispute Resolution. If the average of the 3 years of survival measurements is no more than 0.5 percent below the survival standard, the Coordinating Committee may
decide whether an additional year of study is appropriate. If an additional year of study is undertaken, the study result (if valid) will be included in the calculation of the arithmetic mean.

The testing shall reflect Representative Environmental Conditions and Representative Operational Conditions for each test, for each Plan Species and life history. Studies conducted during years where flow conditions, during the study, fall between the 10% and 90% points on the Flow Duration Curve (See Section 14, Figure 2a and 2b) shall be considered to have satisfied Representative Environmental Conditions (See Section 13, “Representative Environmental Conditions”). Should flow conditions fall outside the 10% and 90% points on the Flow Duration Curve, then the Coordinating Committee, following unanimous approval, may utilize this information in the calculation of the three-year average. The use of survival studies that fall outside the 10% and 90% points on the Flow Duration Curves shall not be subject to Dispute Resolution. The Flow Duration Curves shall be subject to periodic review based upon new information.

The testing shall consider direct, indirect and delayed mortality wherever it may occur and can be measured (as it relates to the Project) given the available mark-recapture technology. The Coordinating Committee shall facilitate the availability of test fish for studies that may include rearing of additional fish beyond that required to meet NNI.

4.2 Phased Implementation Plans.


This Agreement shall be implemented in three phases. Under Phase I, the District shall implement 1) juvenile and adult operating plans and criteria to meet the Survival Standards set forth in sub-Section 4.1 (Survival Standards) and 2) a monitoring and evaluation program to determine compliance with the standards. Following the completion of the three-year monitoring and evaluation program in Phase I, the Coordinating Committee will determine whether the pertinent survival standards have been achieved. Depending on the results of this determination, the District will either proceed to Phase II (if the applicable survival standard has not been achieved) or Phase III (if the applicable survival standards has been achieved). In addition, three separate sub-phases were established within Phase III. The three sub-Phase designations are referred to as Phase III (Standards Achieved), Phase III (Provisional Review) and Phase III (Additional Juvenile Studies). The Parties to this Agreement established separate sub-phases within Phase III as a way to address existing limitations in the
measurement of adult survival and Juvenile Project Survival for sockeye and
subyearling chinook (See Section 14, Figure 1).

The Parties recognize that Douglas PUD has completed the three years of valid
Juvenile Project Survival studies as documented in Section 15, Appendix B. The
Parties further recognize that the District has achieved the 93% Juvenile Project
Survival goal for yearling chinook and steelhead and that once this Agreement is
implemented the District will move into Phase III (Standard Achieved) for these
Plan Species. The District also recognizes that project survival information is
currently limited for yearling chinook and steelhead originating from the
Okanogan Basin. As a result, future Project Survival Studies (e.g. 10 year
standards verification studies) shall consider and attempt to quantify the effect of
the Wells reservoir on Okanogan origin yearling chinook and steelhead.

Measurement and evaluation of 91% Combined Adult and Juvenile
Project Survival or 93% Juvenile Project Survival or the measurement or
calculation of 95% Juvenile Dam Passage Survival will be assessed by the
Coordinating Committee by 2002. Measurement of Juvenile Project Survival or
Juvenile Dam Passage Survival during Phase I is expected to take three years to
complete, unless additional years of study are agreed to by the Coordinating
Committee.

Juvenile survival studies conducted during Phase I (See Section 15,
Appendix B) may result in different phase designations for each of the Plan
Species. For example, the District will move to Phase II (Interim Tools) or
(Additional Tools), or to Phase III (Standard Achieved, Provisional Review or
Additional Juvenile Studies) as described in Figure 1, depending on the survival
results for individual Plan Species. At the conclusion of Phase I, the
Coordinating Committee will determine the appropriate phase designation for
each Plan Species. If the Coordinating Committee cannot agree, the
Coordinating Committee may agree to require an additional year of study to
resolve the disagreement, or a Party may institute Section 11 (Dispute
Resolution) to address the need for additional Measures during the period of
measurement and evaluation.

4.2.2 Phase II.
If the Coordinating Committee has determined, based upon Phase I
monitoring and evaluation or Phase III periodic monitoring, that Juvenile Project
Survival is less than 91% or Juvenile Dam Passage Survival (measured or
calculated) is less than 95%, the District shall move to Phase II for that Plan
Species.
4.2.3 Phase II -- (Interim Tools). If measurement and evaluation of Phase I concludes that the applicable survival standard has not been achieved, then the Wells bypass flow will be increased to 4.4 kcfs per bypass at night (1 hour before sunset to sunrise) for the period during which 80% of the Plan Species not meeting the Juvenile Dam Passage Survival Standard pass the Wells Project or for 40 days, whichever is less. The effect of increased bypass flows will be evaluated to determine if either 95% Juvenile Dam Passage Survival or the 93% Juvenile Project Survival or the 91% Combined Adult and Juvenile Project Survival levels are being attained. The Coordinating Committee will determine the number of valid studies (not to exceed three years of study) necessary to make a Phase determination following the implementation of Interim Tools. If the Combined Adult and Juvenile Survival or the Juvenile Project Survival goals are being achieved, as measured by the re-assessment studies, the District will advance to Phase III (Standards Achieved). If Juvenile Project Survival is re-evaluated and determined to be less than 93% and greater than or equal to 91%, then the Parties shall proceed to Phase III (Provisional Review). If Juvenile Dam Passage is re-evaluated and determined to be greater than or equal to 95%, then the Parties shall proceed to Phase III (Additional Juvenile Studies). If Juvenile Dam Passage Survival continues to be less than 95% and Juvenile Project Survival continues to be less than 91%, then the District shall proceed to Phase II (Additional Tools).

4.2.4 Phase II – (Additional Tools). The Coordinating Committee shall jointly decide on additional Tools, for the District to implement in order to achieve the pertinent survival standard(s) using the following criteria:

1. Likelihood of biological success;

2. Time required to implement; and

3. Cost-effectiveness of solutions, but only where two or more alternatives are comparable in their biological effectiveness.

Until the pertinent survival standard is achieved, the Parties shall continue to implement Phase II (Additional Tools) for the standard and for each Plan Species that is not meeting the pertinent survival standard, except as set forth in sub-Section 2.2.1 (Enough Already) and sub-Section 2.2.4 (Impossibility). The Coordinating Committee will determine the number of valid studies (not to exceed three years of study) necessary to make a Phase determination following the implementation of Additional Tools.
4.2.5 **Phase III (Standard Achieved or Provisional Review or Additional Juvenile Studies).**

The District proceeds to Phase III upon a determination by the Coordinating Committee that the District has 1) verified compliance with the Combined Adult and Juvenile Survival or measured Juvenile Project Survival (Standard Achieved), 2) has evaluated Juvenile Project Survival at less than 93% but greater than or equal to 91% (Provisional Review), or 3) has measured or calculated 95% Juvenile Dam Passage Survival (Additional Juvenile Studies). In short, Phase III indicates that the appropriate standard has either been achieved or is likely to have been achieved and provides additional or periodic monitoring to ensure that survival of the Plan Species remains in compliance with the survival standards set forth in Section 4 (Passage Survival Plan) for the term of the Agreement.

4.2.5.1 **Phase III (Standard Achieved).** The District shall proceed to Phase III (Standard Achieved) following measurement and evaluation that indicate that either the 91% Combined Adult and Juvenile Survival Standard or 93% Juvenile Project Survival is being achieved. In this case, the District shall re-evaluate performance under the applicable standards every 10 years. The Coordinating Committee shall pick representative species for all Plan Species. However, only one species will be utilized to represent spring migrants and one species for summer migrants. This re-evaluation will occur over one year and be included in the pertinent average for that particular species. If the survival standard is met, then Phase III (Standards Achieved) status will remain in effect. If the survival standard is not achieved, then an additional year of testing will occur. If the survival standard remains un-achieved over three years of re-evaluation, then Phase II (Interim or Additional Tools) will take affect for the species evaluated. The Coordinating Committee shall then consider re-evaluating the passage survival of other Plan Species. If the survival standards are exceeded then passage Measures at the Dam shall remain in effect, however supplementation rates may be adjusted from the 7% level based on actual project survival as described in sub-Section 8.4.4. (Adjustment of Hatchery Compensation – Survival Studies).

4.2.5.2 **Phase III (Provisional Review).** The District shall proceed to Phase III (Provisional Review) when Juvenile Project Survival is measured at less than 93% but greater than or equal to 91%. Provisional Review allows the District a one time (Plan Species specific) five year period to implement additional Measures or conduct additional Juvenile Dam Passage Survival Studies or Juvenile Project Survival Studies or Combined Adult and Juvenile Survival Studies. The results of the
Provisional Review Studies will be evaluated by the Coordinating Committee to more accurately determine whether the pertinent survival standard is being achieved. The Coordinating Committee will determine the number of valid studies (not to exceed three years of study) necessary to make a Phase determination following the completion of the Provisional Review survival studies. The Parties will then proceed based upon the results of these new studies. During Phase III (Provisional Review), supplementation levels shall be maximized at 7% for the affected Plan Species and 2% compensation shall be provided by the District to the Plan Species Account.

When the Provisional Review studies indicate that the Combined Adult and Juvenile Survival estimates are greater than or equal to 91% or when the Juvenile Project Survival studies indicate that survival is greater than or equal to 93% then the District shall proceed to Phase III (Standard Achieved).

If the Provisional Review studies indicate that the 95% Juvenile Dam Passage Survival standard has been achieved through direct measurement or calculation, then the District shall proceed to Phase III (Additional Juvenile Studies).

If after the one time, five-year Provisional Review period, Juvenile Project Survival is still less than 93% and greater than or equal to 91% and the Combined Adult and Juvenile Survival studies are inconclusive, then the District will revert back to Phase II (Interim Tools). If the increased bypass flows implemented under Phase II (Interim Tools) do not achieve either 95% Juvenile Dam Passage Survival or 93% Juvenile Project Survival, the District shall proceed to Phase II (Additional Tools).

4.2.5.3 Phase III (Additional Juvenile Studies). The District shall proceed to Phase III (Additional Juvenile Studies) when Juvenile Dam Passage Survival studies or Juvenile Dam Passage calculations indicate that Juvenile Dam Passage Survival is greater than or equal to 95%. Because measurement or calculation of Juvenile Dam Passage Survival does not address juvenile mortality in the pool or the indirect effects of juvenile project passage, the District will evaluate either the 91% Combined Adult and Juvenile Project Survival or the 93% Juvenile Project survival as determined appropriate by the Coordinating Committee. If at any time during Phase III (Additional Juvenile Studies), the Coordinating Committee approves the use of new survival methodologies, the District will have five years to conduct the appropriate evaluation(s). The Coordinating Committee will determine the number of valid studies (not to exceed three years of study) necessary to make a Phase determination under Additional Juvenile Studies. The Parties will then proceed based upon the results of these new studies. During Phase III (Additional
Juvenile Studies), supplementation levels shall be maximized at 7% for the affected Plan Species and 2% compensation shall be provided by the District to the Plan Species Account.

4.3 **Wells Dam Juvenile Dam Passage Survival Plan.**

4.3.1 The District will continue to implement a bypass program of controlled Spill using five (5) bypass baffles at the Wells Project to meet the criteria set out below.

(a) No turbine will be operated during the juvenile migration period unless the adjacent bypass system is operating according to the following criteria.

(b) The five (5) bypass system bays will be Nos. 2, 4, 6, 8, and 10. Operation of the turbines will be in pairs with the associated bypass system bays as follows:

<table>
<thead>
<tr>
<th>Turbines Operated</th>
<th>Bypass Bays Operated</th>
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<tbody>
<tr>
<td>1 and/or 2</td>
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<tr>
<td>3 and/or 4</td>
<td>4</td>
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<td>5 and/or 6</td>
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<td>7 and/or 8</td>
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<tr>
<td>9 and/or 10</td>
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(For example, if turbines 1, 5, and 6 are operating, bypass systems 2 and 6 will be operating.)

(c) At least one bypass will be operating continuously throughout the juvenile migration period, even if no turbines are operating.

(d) The bypass systems and spillgates will be operated in configuration K of the 1987 bypass system report (bottom Spill, 1 foot spill gate opening, 2,200 cfs, vertical baffle opening) for all bypass system bays.

(e) Top Spill has been shown to be as effective as bottom Spill in bypass bays 2 and 10, therefore, top Spill will be allowed in these bays.

(f) If the Chief Joseph Dam Uncoordinated Discharge Estimate is 140,000 cubic feet per second (140 Kcfs) or greater for the following day, all five bypass systems will be operated continuously for 24 hours regardless of turbine unit operation.

(g) If the Chief Joseph Dam Uncoordinated Discharge Estimate is less than 140 Kcfs, bypass system operation will be as follows:
<table>
<thead>
<tr>
<th>Number Turbines Operating</th>
<th>Minimum Number Bypass Systems Operating</th>
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</thead>
<tbody>
<tr>
<td>10</td>
<td>5</td>
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<tr>
<td>9</td>
<td>5</td>
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4.3.2 The District shall operate the bypass system continuously between April 10 and August 15. Initiation of the bypass system may occur between April 1 and April 10 when it can be demonstrated that greater than 5% of the spring migration takes place prior to April 10. The basis for making this determination shall be the historical hydro-acoustic index, verified by historical species composition information. Termination of the bypass system between August 15 and August 31 will occur when it can be demonstrated that 95% of the summer migration has passed the project. The basis for making this determination shall be the historic hydro-acoustic index, verified by the historical species composition information. The bypass will not operate past August 31 unless a Party to this Agreement provides credible scientific evidence to the Coordinating Committee that the run timing is such that a significant component of a Plan Species migrates through the Forebay, Dam and Tailrace outside the usual migration period (April 1 through August 31).

Run timing information will be gathered through the 2002 migration. The Historic Hydroacoustic and Fyke Netting information (1982 – 2002) will be used to verify that 95% of the spring and 95% of the summer migrations are being protected by operating the bypass system from April 10 through August 15.

After the 2002 migration, changes to the April 10 through August 15 operation may be agreed to by the Coordinating Committee based upon historical hydroacoustic and species composition information that would provide bypass operations for 95% of the spring and 95% of the summer migration of juvenile Plan Species.

Additional hydroacoustic and species composition monitoring shall be conducted once every 10 years in order to verify that a significant component (greater than 5%) of the juvenile migration is not present outside the normal bypass operating period (April 10 through August 15) and to verify that the...
operations established by the Coordinating Committee are adequately protecting 95% of the spring and summer migrations of juvenile Plan Species.

4.3.3 Predator Control Measures shall be implemented by the District and will consist of both northern pikeminnow removal and piscivorous bird harassment and control Measures. The northern pikeminnow removal program may include a pikeminnow bounty program, fishing derbies and tournaments, the use of long lines and trapping. Piscivorous bird populations, which include, Caspian terns, double-crested cormorants, and various gull species will be hazed. Hazing techniques may include elaborate wire arrays in the tailrace to deter foraging, propane cannons, various pyrotechnics, and lethal control when necessary. This program will continue to run during the juvenile outmigration.

4.4 Adult Passage Plan. The District shall emphasize adult project passage Measures in order to give high priority to adult survival in the achievement of 91% Combined Adult and Juvenile Project Survival for each Plan Species. The District shall use Tools, including but not limited to the following.

4.4.1 The District shall use best efforts to maintain and operate adult passage systems at the Project according to criteria developed through the Coordinating Committee and as provided in Appendix A: Wells Hydroelectric Project, Adult Fish Passage Plan.

4.4.2 The District shall operate Spill and turbine units in a manner that provides for adult passage while meeting the pertinent juvenile survival standard.

4.4.3 Areas within the adult fish passage systems which are identified by the Coordinating Committee as either consistently out of criteria or where significant delay occurs (as it relates to the biological fitness of the adult Plan Species) shall be modified as soon as feasible.

4.4.4 The District shall use best efforts to eliminate identified sources of adult injury and mortality during adult migration through the Dam.

4.4.5 By the end of Phase I, the District shall identify adult fallback rates at the Dam. This evaluation will include the magnitude of voluntary and involuntary fallback, and will assess the effects of ladder trapping, project operations, the Wells Fish Hatchery and downstream tributaries upon observed rates of fallback. This assessment will also determine the biological significance of these fallback events on the overall fitness of adult Plan Species. If the observed rates of adult fallback and steelhead kelt loss are determined to be significant, then the Coordinating Committee shall determine the most cost

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effective methods to protect adult fallbacks and steelhead kelts at the Dam, and the District shall immediately implement the Measures. Reduction in fallback rates, mortalities and protection of kelts shall be factored into juvenile bypass and adult passage development and implementation and into Project operation decisions.

4.4.6 The Parties to this Agreement recognize that current technology does not allow for a precise estimate of hydroelectric project induced mortality to adult salmonids. Until adult survival studies can accurately differentiate between natural and hydro-project induced mortality, the District shall use the best available technology to conduct, on a periodic basis, adult passage verification studies toward the diagnosis of adult loss, injury and delay at Wells Dam. Prior to the completion of adult survival studies, compensation for adult mortality shall be assumed completely fulfilled by the District’s contribution to the Plan Species Account. Following the completion of adult survival studies, should adult survival rates fall below 98% but the Combined Adult and Juvenile survival rate be maintained above 91%, additional hatchery compensation for that portion of adult losses that exceeds 2%, toward a maximum contribution of 7% compensation provided through hatchery programs and 2% tributary funding, would be utilized to satisfy NNI compensation requirements for each Plan Species.

4.4.7 Pursuant to the 2000 Biological Opinion (BiOp) for the Federal Columbia River Power System, the federal action agencies are required to conduct a comprehensive evaluation to assess adult survival at federal dams. The BiOp sets forth a series of evaluation methods to be employed. The Coordinating Committee should review the information and techniques utilized in those studies and evaluate their potential for accurately measuring Combined Adult and Juvenile Project Survival. The Coordinating Committee should also evaluate technologies found at the federal dams to increase adult survival for possible implementation at the Project. Based upon those evaluations, the District shall implement as necessary, technologies appropriate for the Project.
SECTION 5
RESERVOIR AS HABITAT AND WATER QUALITY

5.1 When making land use or related permit decisions on Project owned lands that affect reservoir habitat, the District shall consider the cumulative impact effects in order to meet the conservation objectives of the Agreement, requirements of the FERC license, and other applicable laws and regulations. The District further agrees to notify and consider comments from the Parties to the Agreement regarding any land use permit application on Project owned lands.

5.2 The District shall notify all applicants for District permits to use or occupy Project lands or water that such use or occupancy may result in an incidental take of species listed as endangered or threatened under the ESA, requiring advance authorization from NMFS or USFWS.

5.3 The Parties recognize that there are potential water quality issues (temperature and dissolved gas) related to cumulative hydropower operations in the Columbia River. The Parties will work together to address water quality issues.

SECTION 6
COORDINATING COMMITTEE

6.1 Establishment of Committee. There shall be a Coordinating Committee composed of one (1) representative of each Party, provided, that the District’s Power Purchasers may participate as a non-voting observer through a single representative, whom they will designate from time to time. Each representative shall have one vote. Each Party shall provide all other Parties with written notice of its designated representative to the Coordinating Committee.

6.2 Meetings. The Coordinating Committee shall meet whenever requested by any two (2) members following notice (unless waived).

6.3 Meeting Notice. The chair of the Coordinating Committee shall provide all committee members with a minimum of ten (10) Days advanced written notice of all meetings unless a member waives notice in writing or reflects the waiver in the approved meeting minutes. The notice shall contain an agenda of all matters to be addressed and voted on during the meeting.
6.4 **Voting.** The Coordinating Committee shall act by unanimous vote of those members present in person or by phone for the vote and shall develop its own rules of process, provided, that the chair shall ensure that all members are sent notice regarding agenda items that may be brought to a vote during the proposed Coordinating Committee meeting. Abstention does not prevent a unanimous vote. If a Party or its designated alternate cannot be present for an agenda item to be voted upon at a Coordinating Committee meeting, the Party must notify the chair of the Coordinating Committee who shall delay a vote on an agenda item for up to five business days on specified issue(s) to be addressed in a meeting and conference call scheduled with all interested Parties, or as otherwise agreed to by the Coordinating Committee. A Party may invoke this right only once per delayed item. If the Coordinating Committee cannot reach agreement, then upon request by any Party, that issue shall be referred to Dispute Resolution.

6.5 **Chair of the Coordinating Committee.** The Parties shall choose and the District shall fund a neutral third party to act as the chair the Coordinating Committee. The chair is expected to prepare an annual list of understandings based on the results of studies (See below sub-Section 6.7 (Authority)), prepare progress reports, prepare meeting minutes, facilitate and mediate the meetings, and assist the members of the Coordinating Committee in making decisions. At least every three years, the Coordinating Committee shall evaluate the performance of the chair of the Coordinating Committee.

6.6 **Use of Coordinating Committee.** The Coordinating Committee will be used as the primary means of consultation and coordination between the District and the FP in connection with the conduct of studies and implementation of the Measures set forth in this Agreement and for Dispute Resolution. Any entity not executing this Agreement shall not be a Party to this Agreement and shall not be entitled to vote on any committee established by this Agreement. However, any Committee established by this Agreement may agree to allow participation of any governmental entities not a Party to this Agreement.

6.7 **Authority.** The Coordinating Committee will oversee all aspects of standards, methodologies, and implementation. The Coordinating Committee shall 1) establish the protocol(s) and methodologies to determine whether or not the survival standards contained within Section 4 (Passage Survival Plan) are being achieved for each Plan Species; 2) determine whether the Parties are carrying out their responsibilities under this Agreement; 3) determine whether NNI is achieved; 4) determine the most appropriate standard in Section 4 (Passage Survival Plan) to be measured for each Plan Species; 5) approve all studies prior to implementation; and 6) review study results, determine their
applicability, and develop an annual list of common understandings based on the studies; 7) periodically adjust the Measures (after Phase I) to address survival and Unavoidable Project Mortality as provided herein; provide that no more than 9% Unavoidable Project Mortality shall be replaced through hatchery and tributary compensation without concurrence of the Coordinating Committee, and hatchery compensation shall not exceed 7% and tributary funding shall not exceed 2% unless agreed to by the Coordinating Committee; 8) resolve disputes brought by the Hatchery and Tributary Committees, and (9) adjust schedules and dates for performance. If the Coordinating Committee cannot reach agreement, then these decisions shall be referred to Dispute Resolution as set forth in Section 11 (Dispute Resolution).

6.8 Studies and Reports. All studies and reports prepared under this Agreement will be available to all members of the Coordinating Committee as soon as reasonably possible. Draft reports will be circulated through the Coordinating Committee representatives for comment, which shall be due within 60 Days unless the Coordinating Committee decides otherwise, and comments will either be addressed in order or made an appendix to the final report. All reports will be kept on file with the District. All studies will be conducted following techniques and methodologies accepted by the Coordinating Committee. All studies will be based on sound biological and statistical design and analysis. The Coordinating Committee shall have the ability to select an independent, third party for the purpose of providing an independent scientific review of any disputed survival study results and/or reports.

6.9 Progress Reports: Each year, with assistance from the chair of the Coordinating Committee, the Hatchery Committee, and the Tributary Committee shall prepare an annual report to the Coordinating Committee describing their progress. Each year, the Coordinating Committee shall prepare an annual report to the Parties describing progress toward achieving the survival standards contained within Section 4 (Passage Survival Plan), and common understandings based upon studies. By March 2013, a comprehensive progress report shall be prepared by the District, at the direction of the Coordinating Committee, assessing overall status of achieving NNI. The Coordinating Committee shall direct an analysis to determine whether each Plan Species is rebuilding. Comprehensive progress reporting shall continue to occur at successive ten-year intervals.
SECTION 7
TRIBUTARY CONSERVATION PLAN

7.1 Tributary Plan. The Tributary Conservation Plan (Tributary Plan) consists of this Agreement and is supported by Supporting Document D, (Tributary Plan, Project Selection, Implementation, and Evaluation). The Tributary Plan is also supported by Supporting Document A (Aquatic Species and Habitat Assessment: Wenatchee, Entiat, Methow, and Okanogan Watersheds). The Parties recognize that Supporting Document A and D do not, by themselves, create contractual obligations.

7.2 Purpose. Under the Tributary Plan, the District shall provide a Plan Species Account to fund projects for the protection and restoration of Plan Species habitat within the Columbia River Watershed (from the Chief Joseph Tailrace to the Wells Tailrace) and the Methow, and Okanogan watersheds, in order to compensate for up to two percent Unavoidable Project Adult and/or Juvenile Mortality; provided that the Parties shall not be required to actually measure whether the Tributary Plan compensates for up to two percent Unavoidable Adult Project Mortality.

7.3 Tributary Committee.

7.3.1 Establishment of Committee. There shall be a Tributary Committee composed of one (1) representative of each Party, provided that an entity eligible to appoint a representative to the Tributary Committee is not required to appoint a representative, and further provided that, representatives from USFWS shall participate in a non-voting, ex-officio capacity unless they otherwise state in writing, and further provided that, the Power Purchasers may participate as a non-voting observer through a single representative, whom they will designate from time to time. The Tributary Committee may select other expert entities, such as land and water trusts/conservancy groups to serve as additional, non-voting members of the Tributary Committee. Each entity eligible to appoint a representative to the Tributary Committee shall provide all other eligible entities with written notice of its designated representative. The Tributary Committee is charged with the task of selecting projects and approving project budgets from the Plan Species Account for purposes of implementing the Tributary Plan.

7.3.2 Full Disclosure. After full written disclosure of any potential conflict of interest, which shall appear in the minutes of the Tributary Committee and prior to project approval, the Tributary Committee may approve a project that may benefit a person or entity related to a committee member, or an entity which appointed the committee member.
7.3.3 Meetings. The Tributary Committee shall meet not less than twice per year at times determined by the Tributary Committee. Additionally, the Tributary Committee may meet whenever requested by any two (2) members following a minimum of ten (10) Days advance written notice to all members of the Tributary Committee unless a member waives notice in writing or reflects the waiver in the approved meeting minutes. The notice shall contain an agenda of all matters to be addressed during the meeting including items that may be brought to a vote during the meeting.

7.3.4 Voting. Except as set forth in sub-Section 7.3.7.1 (Prohibited Use of Account), the Tributary Committee shall act by unanimous vote of those members present in person or by phone for the vote and shall develop its own rules of process, provided, that the chair shall ensure that all members are sent notice of all Tributary Committee meetings. Abstention does not prevent a unanimous vote. If a Party or its designated alternative cannot be present for an agenda item to be voted upon, the Party must notify the chair of the Tributary Committee who shall delay a vote on an agenda item for up to five business days on specified issue(s) to be addressed in a meeting or conference call with all interested Parties, or as otherwise agreed to by the Tributary Committee. A Party may invoke this right only once per delayed item. If the Tributary Committee cannot reach agreement, then upon request of any Party, that issue shall be referred to the Coordinating Committee.

7.3.5 Chair of the Tributary Committee. The Parties shall choose and the District shall fund a neutral third party to chair the Tributary Committee meetings. The chair of the Tributary Committee shall have the same responsibilities and authorities with regard to the Coordinating Committee. At least every three years, the Tributary Committee shall evaluate the performance of the chair of the Tributary Committee.

7.3.6 Coordination With Other Conservation Plans. Whenever feasible, projects selected by the Tributary Committee shall take into consideration and be coordinated with other conservation plans or programs. Whenever feasible, the Tributary Committee shall cost-share with other programs, seek matching funds, and “piggy-back” programs onto other habitat efforts.
7.3.7 **Plan Species Account.** The District shall establish a Plan Species Account in accordance with applicable provisions of Washington State law and this Agreement. Interest earned on the funds in the Plan Species Account shall remain in the Plan Species Account. The Parties to this Agreement may audit the District’s records relating to the Account during normal business hours following reasonable notice. The Tributary Committee shall select projects and approve project budgets from the Plan Species Account by joint written request of all members of the Tributary Committee. The Tributary Committee shall act in strict accordance with sub-Section 7.3.7.1 (Prohibited Uses of Account).

7.3.7.1 **Prohibited Uses of Account.** No money from the Plan Species Account shall be used to enforce compliance with this Agreement. Members of the Tributary Committee and their expenses to attend and participate in Tributary Committee meetings shall not be compensated through the Plan Species Account. Administrative costs, staffing and consultants, reports and brochures, landowner assistance and public education costs collectively shall not exceed $80,000 (1998 dollars) in any given year without the unanimous vote of the Tributary Committee.

7.3.7.2 **Financial Reports.** At least annually, the District shall provide financial reports of Plan Species account activity to the Tributary Committee.

7.3.7.3 **Selection of Projects and Approval of Budgets.** The Tributary Committee shall select projects and approve budgets for expenditure from the Plan Species Account for the following: (1) Any action, structure, facility, program or measure (referred to herein generally as “tributary projects”) intended to further the purpose of the Tributary Plan for Plan Species. Tributary Projects shall be chosen based upon the guidelines set forth in Supporting Document D, “Tributary Compensation, Project Selection, Implementation, and Evaluation” and Supporting Document A, “Aquatic Species and Habitat Assessment: Wenatchee, Entiat, Methow, and Okanogan Watersheds”. Tributary Projects shall not be implemented outside the area specified in sub-Section 7.2 (Purpose). High priority shall be given to the acquisition of land or interests in land such as conservation easements or water rights or interests in water such as dry year lease options; (2) studies, implementation, monitoring, evaluation, and legal expenses associated with any project financed from the Plan Species Account; and (3) prior approved administrative expenses associated with the Plan Species Account.
7.3.7.4 Ownership of Assets. The Tributary Committee shall make determinations regarding ownership of real and personal property purchased with funds from the Plan Species Account. Title may be held by the District, by a resource agency or tribe or by a land or water conservancy group, as determined by the Tributary Committee. Unless the Tributary Committee determines that there is a compelling reason for ownership by another entity, the District shall have the right to hold title. All real property purchased shall include permanent deed restrictions to assure protection and conservation of habitat.

7.3.7.5 Account Status Upon Termination. Upon the Agreement’s termination, (1) the District’s unspent advanced contributions to the Plan Species Account shall be promptly released to the District, (2) if funds remain in the Plan Species Account after the return of the District’s advance contributions, then the Tributary Committee shall remain in existence and continue to operate according to the terms of this Agreement until the funds in the Plan Species Account are exhausted, and 3) all real and personal property which the District holds title shall remain its property.

7.4 Funding.

7.4.1 The District shall make an initial contribution of $1,982,000 in 1998 dollars to the Plan Species Account. Five years after the initial contribution to the Plan Species Account, the District shall do one of the following: 1) make annual payments of $176,178 (2%) in 1998 dollars as long as the Agreement is in effect; or 2) provide an up front payment of $1,761,780 (2% for 10 years) in 1998 dollars, but deducting the actual cost of bond issuance and interest.

7.4.2 The District’s funding of the Plan Species Account will be considered to be full and complete compensation for adult mortality associated with the Wells Hydroelectric Project until the actual adult survival rate can be accurately determined.

7.4.3 If the adult survival rate is determine to be equal to or greater than 98% and the Juvenile Project Survival rates is determined to be greater than 93%, the Tributary Fund will be reduced to reflect the actual adult survival estimate of the four Permit Species. Adult survival estimates for each Permit Species will independently determine one quarter of the Plan Species Account (See Example 1).
7.4.4 If the Juvenile Project Survival rate for each Plan Species is less than 93% but the Combined Adult and Juvenile Project Survival rate is maintained above 91%, the Plan Species Account may be used to compensate for juvenile losses, with a maximum compensation rate of 2%.

7.4.5 The choice of annual or up front payment under sub-Sections 7.4.1 shall be made by the FP.

7.4.6 If the “up front payment option” is selected then at the end of 15 years, the Parties will determine the distribution of the remaining funds to the Plan Species Account in amounts equivalent to annual payments of $176,178.00 in 1998 dollars.

7.4.7 The first installment is due within ninety (90) Days of the effective date of the Agreement. The rest of the installments are due by the 31st day of January each year thereafter. The dollar figures shall be adjusted for inflation on the 1st day of January each year based upon the Consumer Price Index for all Urban Consumers for the Seattle/Tacoma area, published by the U.S. Department of Labor, Bureau of Labor Statistics. If said index is discontinued or becomes unavailable, a comparable index suitable to the Tributary Committee shall be substituted.

7.5 Tributary Assessment Program.
The District shall provide support for a Tributary Assessment Program separate from the Plan Species Account. The Tributary Assessment Program will be utilized to monitor and evaluate the relative performance of tributary enhancement projects approved by the Tributary Committee and directly funded by the initial contribution to the Plan Species Account (See Section 7.4.1). It is not the intent of the Tributary Assessment Program to measure whether the Plan Species Account has provided a 2% increase in survival for Plan Species. Instead, the program has been established to ensure that the dollars allocated to the Plan Species Account are utilized in an effective and efficient manner. The District shall develop, in coordination with and subject to approval by the Tributary Committee, the measurement protocols for the Tributary Assessment Program. The Tributary Committee may choose to either evaluate the relative merits of each individual tributary enhancement project or it may choose to evaluate an aggregation of projects provided that the total cost associated with the Tributary Assessment Program does not exceed $200,000 (not subject to inflation adjustment).
Example 1. Adult steelhead and spring chinook survival measured at 99% but no other adult Permit Species have been studied. Tributary funding would remain at 2% for sockeye and summer/fall chinook but would be reduced to 1% based upon the results from the adult steelhead and spring chinook survival studies. Annual Contributions to the Plan Species Account would reduce the prospective payments from a full 8/8 contribution to a 6/8 contribution.

Plan Species Account Calculations:

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<thead>
<tr>
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<th>Before Adult Studies</th>
<th>After Adult Studies</th>
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<tr>
<td>Steelhead</td>
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<tr>
<td>Spring Chinook</td>
<td>(2%)</td>
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<tr>
<td>Summer/Fall Chinook</td>
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<tr>
<td>Sockeye</td>
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8/8th

SECTION 8
HATCHERY COMPENSATION PLAN

8.1 Hatchery Objectives.

8.1.1 The District shall provide hatchery compensation for all of the Permit Species including; a) spring chinook salmon, b) summer/fall chinook salmon, c) sockeye salmon, d) summer steelhead as further described in Section 8 (Hatchery Compensation Plan). The District shall also provide hatchery compensation for coho salmon should they become established under the criteria set forth in Section 8.4.5.1 (Coho).

8.1.2 The District shall implement the specific elements of the hatchery program consistent with overall objectives of rebuilding natural populations, and achieving NNI. Species specific hatchery program objectives developed by the JFP may include contributing to the rebuilding and recovery of naturally reproducing populations in their native habitats, while maintaining genetic and ecologic integrity, and supporting harvest. This compensation may include Measures to increase the off-site survival of naturally spawning fish or their progeny (i.e. Sockeye Enhancement Decision Tree, Section 14, Figure 3).
8.2 Hatchery Committee.

8.2.1 Establishment of the Committee. There shall be a Hatchery Committee composed of one (1) representative of each Party, provided that a Party is not required to appoint a representative and further provided that the Power Purchasers may participate as a non-voting observer through a single representative whom they will designate from time to time. A Party shall provide all other eligible Parties with written notice of its designated representative.

8.2.2 Responsibilities. The Hatchery Committee shall oversee development of recommendations for implementation of the hatchery elements of this Agreement for which the District has responsibility for funding. This includes overseeing the implementation of improvements and monitoring and evaluation relevant to the District’s hatchery programs, as identified in the Hatchery Compensation Plan, the Permit and this Agreement. The Hatchery Committee shall also coordinate in-season information sharing and shall discuss unresolved issues. The Hatchery Committee decisions shall be based upon: likelihood of biological success, time required to implement, and cost-effectiveness of solutions.

8.2.3 Meeting Notice. The Hatchery Committee shall meet at least twice per year or whenever requested by any two (2) members following a minimum of ten (10) Days advance written notice to all members of the Hatchery Committee unless a member waives notice in writing or reflects the waiver in the approved meeting minutes. The notice shall contain an agenda of all matters to be addressed during the meeting including items that may be brought to a vote during the meeting.

8.2.4 Voting. The Hatchery Committee shall act by unanimous vote of those members present in person or by phone for the vote and shall develop its own rules of process, provided, that the chair shall insure that all members are sent notice of all Hatchery Committee meetings. Abstention does not prevent a unanimous vote. If a Party or its designated alternative cannot be present for an agenda item to be voted upon, then the Party must notify the chair of the Hatchery Committee who shall delay a vote on an agenda item for up to five business days on specified issue(s) to be addressed in a meeting or conference call scheduled with all interested Parties, or as otherwise agreed to by the Hatchery Committee. A Party may invoke this right only once per delayed agenda item. If the Hatchery Committee cannot reach agreement, then upon request of any Party, that issue shall be referred to the Coordinating Committee.
8.2.5 **Chair of the Hatchery Committee.** The Parties shall choose and the District shall fund a neutral third party to chair the Hatchery Committee meetings. The chair shall have the same responsibilities and authorities with regard to the Hatchery Committee as the chair of the Coordinating Committee has with regard to the Coordinating Committee. At least every three years, the Hatchery Committee shall evaluate the performance of the chair of the Hatchery Committee.

8.3 **Hatchery Operations.** The District or its designated agents shall operate the hatchery facilities according to the terms of Section 8 (Hatchery Compensation Plan), the ESA Section 10 permit(s) and in consultation with the Hatchery Committee.

8.4 **Hatchery Production Commitments.**

8.4.1 **Hatchery Agreements.** The District may enter into agreements with other entities for the rearing, release, monitoring and evaluation and research of hatchery obligations. However, it is the District’s responsibility to ensure that their obligations under Section 8 (Hatchery Compensation Plan) are satisfied. The Hatchery Committee must approve any proposed agreements or trades of production.

8.4.2 **Calculation of Hatchery Commitments.** During Phase I, the District shall provide the funding and capacity required of the District to meet the 7% hatchery compensation level necessary to achieve NNI. Juvenile Project Survival estimates, when available, will be used to adjust hatchery based compensation programs and adult survival estimates will be used to adjust the Plan Species Account contribution. However, should adult survival rates fall below 98% but the Combined Adult and Juvenile survival rates be maintained above 91%, additional hatchery compensation for adult losses, toward a maximum contribution of 7% compensation provided through hatchery programs, would be utilized to provide compensation for Unavoidable Project Mortality. The rationale for determining the initial hatchery production commitment requirement is supported by Supporting Document B, “Biological Assessment and Management Plan: Mid-Columbia Hatchery Program”. The Parties recognize that Supporting Document B is a supporting document and does not by itself create contractual obligations.
8.4.3 Phase I Production Commitment. Douglas will continue to fund the operation and maintenance of the Wells Hatchery and Methow Spring Chinook Supplementation Hatchery. The Parties agree that the Phase I production commitments to be provided by the District for juvenile passage losses are satisfied by maintaining current production commitments at existing facilities of 49,200 pounds of spring chinook at about 15 fish per pound (738,000 fish) and 30,000 pounds of summer steelhead at about 6 fish per pound (180,000 fish). Summer chinook passage losses are mitigated with 40,000 pounds of summer chinook at about 10 fish per pound (400,000 fish), currently being satisfied through the species trade with Chelan PUD (40,000 pounds of summer chinook are reared by Chelan PUD in exchange for 19,200 pounds of spring chinook reared by Douglas PUD). A portion of passage losses for sockeye (5%) are satisfied through the substitution of 15,000 pounds of spring chinook production (225,000 fish) at the Methow Hatchery as a species substitution for 9,240 pounds of sockeye (231,000 fish). After 2003 brood, NNI for sockeye will be accomplished through the implementation of a set of options identified in the Sockeye Enhancement Decision Tree (See Section 14, Figure 3). As a result of implementing the Sockeye Enhancement Decision Tree, the District’s spring chinook obligation shall be reduced by 15,000 pounds starting with the 2004 brood.

8.4.4 Adjustment of Hatchery Compensation - Survival Studies. Hatchery production commitments, except for original inundation compensation, shall be adjusted based upon the results of survival studies conducted during Phase I, Phase II and Phase III (Standard Achieved, Additional Juvenile Studies, and Provisional Review). Hatchery compensation for yearling chinook and steelhead shall be adjusted based upon the results from the three years of accurate and precise Juvenile Project Survival studies completed at the Wells Hydroelectric Project. The arithmetic average of the three years of survival study indicate that the survival of yearling chinook and steelhead averages 96.2%. As a result, compensation for spring chinook, yearling summer chinook and steelhead shall be reduced to 3.8% as indicated below:

**Spring Chinook:** The District’s commitment for Methow Basin spring chinook shall be 4,071 pounds at about 15 fish per pound (61,071 smolts). In addition, the District will provide 15,000 pounds of spring chinook at about 15 fish per pound (225,000 fish) through brood year 2003 as compensation for sockeye salmon losses. The District will rear for Chelan PUD, through contractual agreement between the two PUDs, up to 19,200 pounds of spring chinook at about 15 fish per pound (288,000 fish).
**Steelhead:** The passage loss of steelhead shall be mitigated through the production of 8,143 pounds of fish at about 6 fish per pound (48,858 fish).

**Sockeye:** Through spring 2005 (2003 Brood), 15,000 pounds (225,000 smolts) of spring chinook salmon will be raised as species substitution for 9,240 pounds of sockeye. After 2005, NNI for sockeye will be accomplished through the implementation of a set of options identified in the Sockeye Enhancement Decision Tree (See Section 14, Figure 3).

**Summer Chinook:** The District’s commitment for summer chinook shall be 10,857 pounds of yearling summer chinook at about 10 fish per pound (108,570 fish). Chelan PUD, through contractual agreement with Douglas PUD, will rear these fish at the Carlton Acclimation Pond.

### 8.4.5 Adjustment of Hatchery Compensation - Population Dynamics

Hatchery production commitments, except for original inundation mitigation, shall be adjusted in 2013 and every 10 years thereafter to achieve and maintain NNI as required to adjust for changes in the average adult returns of Plan Species and for changes in the adult-to-smolt survival rate and for changes to the smolt-to-adult survival rate from the hatchery production facilities, using methodologies described in Supporting Document B, “Biological Assessment and Management Plan (BAMP): Mid-Columbia Hatchery Program”. However, it should be noted that Supporting Document B is a supporting document and does not by itself create contractual obligations.

Example 2: Juvenile Project Survival for steelhead measured at 96.2% with error of less than 5% at a 95% confidence interval. Hatchery supplementation commitments for steelhead would be established at 3.8% (14% compensation for steelhead under the Wells Settlement Agreement equates to 30,000 pounds of steelhead; 7% compensation for steelhead equates to 15,000 pounds). At a 3.8% compensation rate, steelhead production would be reduced to 3.8/7 of 15,000 pounds or 8,143 pounds of steelhead raised as compensation for mainstem project passage losses. This production would be in addition to the fixed inundation compensation of 50,000 pounds of steelhead. Total steelhead production would be established under Phase III (Standards Achieved) at 58,143 pounds of steelhead at 6 fish per pound.
8.4.5.1 Coho. Compensation for Methow River coho will be assessed in 2006 following the development of an anticipated long-term coho hatchery program and/or the establishment of a Threshold Population of naturally reproducing coho in the Methow Basin. The Hatchery Committee shall make a determination on whether a hatchery program and/or naturally reproducing population of coho is present in the Methow Basin (by an entity other than the District and occurring outside this Agreement). Should the Hatchery Committee determine that such a program and/or population exists, then the Hatchery Committee shall determine the most appropriate means to satisfy NNI for Methow Basin coho. Programs to meet NNI for Methow Basin coho may include but is not limited to; 1) provide operation and maintenance funding in the amount equivalent to 3.8% project passage loss or 2) provide funding for acclimation or adult collection facilities both in the amount equivalent to 3.8% juvenile passage loss at the Wells Project. The programs selected to achieve NNI for Methow Basin coho will utilize an interim value of project survival, based upon the three-year average Juvenile Project Survival estimate of 96.2%, until project survival studies can be conducted on Methow Basin coho.

8.4.5.2 Okanogan Basin Spring Chinook. Compensation for Okanogan Basin spring chinook will be assessed in 2007 following the development of a long-term spring chinook hatchery program and/or the establishment of a Threshold Population of naturally reproducing spring chinook in the Okanogan watershed (by an entity other than the District and occurring outside this Agreement). The Hatchery Committee shall make a determination on whether a hatchery program and/or naturally reproducing population of spring chinook is present in the Okanogan Basin. Should the Hatchery Committee determine that such a program and/or population exists, then the Hatchery Committee shall determine the most appropriate means to satisfy NNI for Okanogan Basin spring chinook. Programs to meet NNI for Okanogan Basin spring chinook may include but not be limited to; 1) provide O & M funding in the amount equivalent to 3.8% project passage loss or 2) replace project passage losses of hatchery spring chinook with annual releases of equivalent numbers of yearling summer chinook into the Okanogan River Basin or 3) provide funding for acclimation or provide funding for adult collection facilities in the amount equivalent to 3.8% juvenile passage loss at the Wells Project. The programs selected to achieve NNI for Okanogan Basin spring chinook will utilize an interim value of project survival based upon the three-year average Juvenile Project Survival estimate of 96.2% until project survival studies can be conducted on Okanogan Basin yearling chinook.
8.4.6 Fixed Hatchery Compensation - Inundation. Of the existing production commitment 50,000 pounds of yearling steelhead at about 6 fish per pound (300,000 fish), 32,000 pounds of yearling summer chinook at about 10 fish per pound (320,000 fish) and 24,200 pounds of subyearling summer chinook, at about 20 fish per pound (484,000 fish), is compensation for original inundation and shall not be subject to adjustment as provided in sub-Section 8.4 (Hatchery Production Commitments).

8.5 Monitoring and Evaluation.

8.5.1 The Hatchery Committee shall develop a five-year monitoring and evaluation plan for the hatchery program that is updated every five years. The first monitoring and evaluation plan shall be completed by the Hatchery Committee within one year following FERC approval of this Agreement. Existing monitoring and evaluation programs will continue until replaced by the Hatchery Committee.

8.5.2 The Parties agree that over the duration of this Agreement new information and technologies may be developed and may be considered in a comprehensive hatchery evaluation program. The District shall fund the comprehensive hatchery evaluation program consistent with the hatchery goals set forth in sub-Section 8.1.2 and 8.4 (Hatchery Production Commitments) and the monitoring and evaluation guidelines as outlined in the BAMP and as determined by the Hatchery Committee.

8.5.3 The Hatchery Committee shall plan and the District shall implement the following steelhead studies that are related to the District’s production program. First, the District shall fund a study to investigate the natural spawning (reproductive) success of hatchery reared steelhead relative to wild steelhead. This study should utilize a statistically valid number of fish necessary to develop baseline DNA profiles for Methow River steelhead. This analysis should be conducted for approximately 5 brood years. The District shall also conduct an assessment of longer-term acclimation for steelhead, using small scale temporary or existing facilities. This study shall continue for approximately 3 brood years and will not compromise in any way on-going supplementation programs at existing facilities.
8.6 Program Modifications.

8.6.1 Hatchery program modifications shall make efficient use of existing facilities owned by the District or cooperating entities including adult collection, acclimation and hatchery facilities, provided that existing facility use is compatible with and does not compromise ongoing programs. The District in consultation with the Hatchery Committee shall make reasonable efforts to implement program modifications when needed to achieve overall and specific program objectives. Program modifications may include changes to facilities, release methods, and rearing strategies necessary to achieve NNI as determined by the monitoring and evaluation program. Program modifications will be made following unanimous agreement of the Hatchery Committee, as set forth in sub-Section 8.2.4 (Voting), to achieve specific program objectives as outlined in Section 8 (Hatchery Compensation Plan), including sub-Section 8.4.4 (Adjustment of Hatchery Compensation – Survival Studies) and sub-Section 8.4.5 (Adjustment of Hatchery Compensation – Population Dynamics), as determined by Section 10 Permit and as defined in monitoring and evaluation plans to be developed. The District will make reasonable efforts to complete program modifications as soon as possible, following agreement with the Hatchery Committee.

8.6.2 As of the date this Agreement is signed by the Parties, two areas have been identified for program modification and improvement. The District working with the Hatchery Committee shall assess program modification options and implement them based upon the results of the assessment, as indicated below.

1) Improve the adult trapping facility efficiency for adult spring chinook returning to the Chewuch River without undue delay in adult migration and/or displacement of natural spawners to non-target areas. In coordination with the JFP, the District will use its best effort to implement trap improvements by removal of rock debris below Fulton Dam (Chewuch River) by May 2002. The Hatchery Committee will assess whether these improvements are sufficient to achieve the trapping objective without changing adult migration/spawning behavior. If the trapping objectives are achieved, no additional improvements will be required. In the event that these repairs do not result in achievement of the trapping objective, the District, working with the Hatchery Committee, will assess the methods to improve trap efficiency including the following options; 1) additional improvements to Fulton Dam, or 2) a new trapping facility. Based on these assessments, the Hatchery Committee shall select a preferred option and an implementation plan shall be developed by the District. The District will complete
program modifications as soon as reasonably possible (possibly 2003), following agreement with the Hatchery Committee.

2) Improve the adult trapping facility efficiency for adult spring chinook returning to the Twisp River without undue delay in adult migration and/or displacement of natural spawners to non-target areas. The Hatchery Committee will assess methods to improve trap efficiency including the following two options; 1) modifying the existing trap and weir or 2) development of a new trapping facility. Based on these assessments, the Hatchery Committee shall select a preferred option and the District shall develop an implementation plan. The District will complete program modifications as soon as reasonably possible (possibly 2003), following agreement with the Hatchery Committee.

8.6.3 In addition to these program modifications and with concurrence from the Hatchery Committee, the District may pursue the development of a memorandum of understanding between parties concerning use of shared facilities, fish, and water rights.

8.6.4 During the duration of the Agreement, NMFS shall have the opportunity to seek hatchery program modifications (that do not change the 7% program levels) but are otherwise necessary to address emergency effects of a hatchery program on listed Permit Species. Such program modifications shall be supported by a minimum of two years of field data from the river or stream in question. Other information documenting a significant and adverse effect on the productivity of listed Permit Species from other rivers can be considered, but only if applicable to the listed Permit Species and stream in question. Any proposal to modify a hatchery program will be documented in a memorandum from the Regional Administrator to the Hatchery Committee summarizing the problem, and then followed by up to six months of Hatchery Committee evaluation. The Parties recognize that initially a portion of the production contemplated in this Agreement will be for purposes of supplementation of Plan Species or re-establishing runs in areas from which they have been extirpated. In the event the concerns raised in this sub-Section (8.6.4) involve the use of such a program, NMFS agrees to take the program design and intent into account in reaching any conclusion regarding the need for emergency modifications.
8.7 Changed Hatchery Policies under ESA.

8.7.1 Except in 2013 and every ten years thereafter, NMFS will refrain from applying hatchery policy decisions that would preclude the 7% hatchery levels (as adjusted) from being achieved. In 2013, and every 10 years thereafter (at the time of the program review), if NMFS proposes hatchery policy decisions that would preclude the 7% hatchery levels (as adjusted) from being achieved, NMFS will (a) propose application of the policies to the Hatchery Committee and seek agreement, (b) propose a revised hatchery program consistent with the principles of NNI and an expeditious transition plan from the existing hatchery program to the revised hatchery program, (c) if agreement is not possible, discuss the application of the policies with the Coordinating Committee and then with the Policy Committee, if necessary, and (d) if agreement is still not possible then allow the issue to be elevated to the Administrator of NMFS. Between 2013 and 2018, except as provided in sub-Section 8.4 (Program Commitments) and 8.6 (Program Modifications), if NMFS fails to allow full utilization of the District’s hatchery capacity to achieve the 7% hatchery levels (as adjusted), this shall not be considered a basis for NMFS withdrawal from the Agreement or revocation of the Permit until 2018. In such a case, the District working with the Parties shall develop a transition plan between 2013 and 2018 to make up for the 7% hatchery levels (as adjusted). The transition plan may be implemented as soon as reasonably possible however the transition plan must be initiated by 2018. The Parties recognize that initially a portion of the production contemplated in this Agreement will be for purposes of supplementation of Plan Species or re-establishing runs in areas from which they have been extirpated. NMFS agrees to take the program design and intent into account in reaching any conclusion.

8.7.2 Until 2013, facility modifications are based on monitoring and evaluations and may not reflect changes in NMFS hatchery policy. During 2013 and every 10 years thereafter (at the time of the program review), facility modifications can also reflect changes in ESA policy with the understanding that a reasonable period of time will be provided to complete the modifications. The 2013 date for achievement of NNI in Section 3.1 will be adjusted if necessary to reflect the time needed to complete such modifications (as determined by the Hatchery Coordinating Committee).

8.8 Program Review. In 2003 and every ten years thereafter, the hatchery evaluations program, including natural population/hatchery interaction studies, will undergo a program review to determine whether or not the applicable hatchery program is operating in a manner that is consistent with the goals outlined in that particular facilities hatchery evaluation plan. In 2013 and every ten years thereafter, the hatchery program will undergo a program review to determine if adult-to-smolt and smolt-to-adult survival standards, hatchery
program goals, and objectives as defined in the Hatchery Plan, the Section 10 Permits, and as further defined in this document have been met or sufficient progress is being made towards their achievement. This review shall include a determination of whether hatchery production objectives are being achieved. The Hatchery Committee shall be responsible for conducting the hatchery program review, developing a summary report, and in the event that program objectives, as defined in sub-Section 8.1 (Hatchery Objectives) above, are not being met, shall be responsible for establishing alternative plans to the District to achieve them. The District shall be responsible for developing and funding implementation plans.

8.9 New Hatchery Facilities. Before being required to construct new hatchery facilities, the Hatchery Committee shall make efficient use of existing or modified facilities owned by the District or entities consenting to the use of their facilities including adult collection, acclimation and hatchery facilities, provided that existing or modified facility use is compatible with and does not compromise ongoing programs.

SECTION 9
ASSURANCES

9.1 Project License. The Parties agree to join with the District’s filing with FERC requesting that FERC issue appropriate orders: (1) to amend the Project’s existing license to include this Agreement as a condition thereof, and (2) to terminate the Wells Settlement Agreement dated October 1, 1990.

9.2 Regulatory Approval.
9.2.1 The Parties shall provide reasonable efforts to expedite any NEPA, SEPA, and other regulatory processes required for this Agreement to become effective. The Parties (except the lead agency) may file comments with the lead agency. Such comments will not advocate additional Measures or processes for Plan Species. The Parties shall provide reasonable efforts to expedite the approval process of the District’s incidental take permit application.

9.3 Regulatory Approval Without Change.
9.3.1 Except for the District’s obligations in sub-Section 10.2 (Permit Issuance) and sub-Section 9.1 (Project License), the terms of this Agreement shall not take effect until the NMFS issues the District a Permit, the FERC issues the required FERC orders and the USFWS completes necessary consultations under the ESA. Provided, the Parties shall continue to conduct planning and study efforts throughout the approval process.
9.3.2 Any Party may withdraw from this Agreement within 60 Days of FERC issuing a license modification in the event that: (1) the NMFS issues the District a Permit with terms and conditions in addition to or different from those set forth in this Agreement, (2) the FERC fails to include this Agreement, in its entirety, or adds terms or conditions inconsistent with this Agreement as a license condition of the current Project license or of the first new long-term Project License approved within the term of this Agreement, or (3) a Party as a result of compliance with NEPA or SEPA requires a material change to the terms or conditions of this Agreement. In order to withdraw from this Agreement, a Party shall provide all other Parties with notice of their intent to withdraw and state in the notice their reason(s) for withdrawing from the Agreement. The ability of a Party to withdraw from this Agreement, pursuant to this paragraph, terminates if not exercised within said period. The notices required by this sub-Section shall be in writing and either served in person or provided by U.S. Mail, return receipt requested.

9.4 Release, Satisfaction and Covenant Not to Sue

9.4.1 The Parties, within the limits of their authority, shall from the date of construction of the Project to the effective date of this Agreement, release, waive, discharge the District and the District’s predecessors, commissioners, agents, representatives, employees, and signatory power purchasers from any and all claims, demands, obligations, promises, liabilities, actions, damages and causes of action of any kind concerning impacts of the Project on Plan Species except for the obligation to provide compensation for original construction impacts of the Project implemented through the hatchery component of this Agreement. This release, waiver, and discharge shall not transfer any of the above listed District liabilities or obligation to any other entity.

9.4.2 Provided that the District is in full compliance with its Permit, this Agreement, and its FERC project license provisions relating to Plan Species, each Party agrees not to institute any action under the ESA, the Federal Power Act, the Fish and Wildlife Coordination Act, the Pacific Northwest Electric Power Planning and Conservation Act and the Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act against the District and its signatory Power Purchasers related to impacts of the Project on Plan Species from the date this Agreement becomes effective through the date this Agreement terminates.

9.4.3 Termination of this Agreement or withdrawal of a Party shall have no effect upon the release provided for in sub-Section 9.4.1.
9.4.4 This Agreement does not affect, limit or address the imposition of annual charges under the Federal Power Act, or the right of any party in any proceeding or forum to request annual charges.

9.5 Re-Licensing.

9.5.1 With respect to Plan Species, the Parties agree to be supportive of the District’s long-term license application(s) to the FERC filed during the term of the Agreement for the time period addressed in this Agreement, provided that the District has adhered to the terms and conditions of this Agreement, the Permit, and the FERC license provisions relating to Plan Species, as well as any future terms, conditions, and obligations agreed upon by the Parties hereto or imposed upon the District by the FERC. To the extent that the District has met such terms and conditions, the Parties agree that the District is a competent license holder with respect to its obligations to Plan Species. If the fifty (50)-year term of this Agreement will expire during a long-term license, any Party may advocate license conditions that take effect after this Agreement expires.

9.5.2 This Agreement shall constitute the Parties’ terms, conditions and recommendations for Plan Species under Sections 10(a), 10(j) and 18 of the Federal Power Act and the Fish and Wildlife Coordination Act, provided that NMFS and USFWS maintain the right to reserve their authorities under Section 18 of the Federal Power Act on the condition that such reserved authority may be exercised only in the event that this Agreement terminates provided further that, the Parties as part of their terms, conditions and recommendations under Section 10(a) of the Federal Power Act may request that Plan Species protection or mitigation Measures contained in a competing license application be included as a condition of the District’s new long-term Project license.

9.5.3 Notwithstanding sub-Section 9.5.2 and sub-Section 9.10 (Drawdowns/Dam Removal/Non-Power Operations), this Agreement does not limit the participation of any Party in any FERC proceeding to assert: (1) any condition for resources and other aspects of the District’s license other than for Plan Species, and (2) to assert conditions for Plan Species to implement this Agreement.

9.6 Limitation of Reopening. During the term of this Agreement, the Parties shall not invoke or rely on any re-opener clause set forth in any FERC license applicable to the Project for the purpose of obtaining additional Measures or changes in project structures or operations for Plan Species, except as set forth in sub-Section 9.5.2 and 9.5.3.
9.7 Additional Measures. This Agreement sets out certain actions, responsibilities, and duties with regard to Plan Species to be carried out by the District and by the JFP to satisfy the legal requirements imposed under the ESA, the Federal Power Act, the Fish and Wildlife Coordinating Act, the Pacific Northwest Electric Power Planning and Conservation Act and the Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act. This Agreement is not intended to prohibit the Parties from opposing or recommending actions in reference to (1) Project modifications such as pool raises and additional power houses, and (2) activities not related to Project operations that could adversely affect Plan Species. The Parties recognize that various Parties to this Agreement have governmental rights, duties, and responsibilities as well as possible rights of action under statutes, regulations and treaties that are not covered by this Agreement. This Agreement does not limit or affect the ability or right of a Party to take any action under any such law, regulation or treaties. However, the Party shall use reasonable efforts to exercise their rights and authority under such statutes, regulations, and treaties (consistent with their duties and responsibilities under those statutes, regulations and treaties) in a manner that allows this Agreement to be fulfilled.

9.8 Title 77 RCW. Provided the District is in compliance with the Agreement, the Permit, and the FERC license provisions relating to Plan Species, WDFW shall not request additional protection or mitigation for Plan Species under Title 77 RCW as now exists or as may be amended, unless WDFW is specifically required to take such action by statute.

9.9 Cooperation in Studies/Approval/Permits. The Parties shall cooperate with the District in conducting studies and in obtaining any approvals or permits which may be required for implementation of this Agreement.

9.10 Drawdowns/Dam Removal/Non-Power Operations. With respect to Plan Species under the ESA, the Federal Power Act, the Fish and Wildlife Coordination Act, the Pacific Northwest Electric Power Planning and Conservation Act, and the Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act each Party during the term of this Agreement will not advocate for or support additional or different fish protection Measures or changes in Project structures or operations other than those set forth in this Agreement. For example, the Parties will not advocate or support partial or complete drawdowns, partial or complete dam removal, and partial or complete non-power operations. However, this Agreement does not preclude: spillway or Tailrace modifications; Spill; structural modifications and concrete removal (holes in Dam) to accommodate bypass; structural modifications to accommodate adult passage facility improvements; and future Wells Agreement

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consideration of additional Measures that may include reservoir elevation changes if all Parties agree. The Parties agree to work within this Agreement to address any issues that may arise in the future concerning Plan Species.

9.11  **Stipulation of Plan Species.** Each Party stipulates that the performance of the District’s obligations under this Agreement, its Permit, and its FERC license will adequately and equitably conserve, protect, and mitigate Plan Species pursuant to the ESA, the Federal Power Act, the Fish and Wildlife Coordination Act, the Pacific Northwest Electric Power Planning and Conservation Act, and the Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act as those Plan Species are affected by the Project through the term of the Agreement.

9.12 **Vernita Bar.** Nothing in this Agreement is intended to affect the protection of Plan Species in the Hanford Reach or the Vernita Bar Agreement, as it exists now or may be modified in the future.

9.13 **Non-Plan Species.** Non-Plan Species are not addressed in this Agreement.

**SECTION 10**

**ENDANGERED SPECIES ACT COMPLIANCE**

10.1  **Scope.** This Section 10 Endangered Species Act Compliance applies only between the NMFS and the District and does not apply to the other Parties unless specifically referenced.

10.2  **Permit Issuance.**

10.2.1  The District shall revise its incidental take permit applications for Permit Species based upon this Agreement and submit a directed take permit application for Hatchery Operations. This Agreement and its Figures and Appendices shall constitute the District’s habitat conservation plan in support of the District’s incidental take permit application. Supporting Documents A, B, C and D are to be used as supporting documents to the Agreement and as such, Supporting Documents A, B, C and D do not, by themselves, create contractual obligations under this Agreement or through the permit issued by NMFS.

10.2.2  NMFS issuance of a Permit to the District assures the District that based upon the best scientific and commercial data available and after careful consideration of all comments received, NMFS has found that with respect to all Permit Species that: (i) any take of a Permit Species by the District under this Agreement will be incidental to the carrying out of otherwise lawful activities; (ii) under this Agreement the District will, to the maximum extent practicable,
minimize and mitigate any incidental take of Permit Species; (iii) the District has sufficient financial resources to adequately fund its affirmative obligations under this Agreement; (iv) as long as the actions required by this Agreement to minimize/mitigate incidental take of Permit Species are implemented, any incidental take of a Permit Species will not appreciably reduce the likelihood of the survival and recovery of such species in the wild; and (v) other Measures and assurances required by NMFS as being necessary or appropriate are included in this Agreement.

10.2.3 After opportunity for public comment, compliance with NEPA and concurrent with the effective date of this Agreement, NMFS will issue a Permit to the District pursuant to Section 10(a)(1)(B) of the ESA to authorize any incidental take of listed Permit Species which may result from the District’s otherwise lawful operation of the Project, conducted in accordance with this Agreement and the Permit (Hatchery permits are addressed in sub-Section 10.2.5). In addition, the Permit shall authorize any incidental take of listed Permit Species which may result from the District’s otherwise lawful operation of the hatchery facilities required by this Agreement, conducted in accordance with this Agreement and the Permit. The Permit and this Agreement shall remain in full force and effect for a period of fifty (50) years from the effective date, or until revocation of the Permit under sub-Section 10.5 (Permit Suspension, Revocation and Re-Instatement), whichever occurs sooner. Amendments to the Permit or this Agreement shall remain in effect for the then-remaining term of this Agreement or until revocation under sub-Section 10.5 (Permit Suspension, Revocation and Re-Instatement), whichever occurs sooner. Withdrawal from this Agreement and revocation of the Permit as provided in Section 2 is not limited by the no surprises regulation. The Permit shall incorporate by reference the no surprises rule set forth in 50 CFR § 222.307 (g) (2001). This Agreement provides for changed circumstances and the mitigation Measures to respond to changed circumstances. Any circumstance relating to Permit Species not addressed by this Agreement is an Unforeseen Circumstance (See Section 13, “Unforeseen Circumstances”).

10.2.4 The Permit shall authorize the District to incidentally take Permit Species that are listed under the ESA, to the extent that such incidental take of such species would otherwise be prohibited under Section 9 of the ESA, and its implementing regulations, or pursuant to a rule promulgated under Section 4(d) of the ESA, and to the extent that the take is incidental to the District’s lawful operation of the Project, subject to the condition that the District must fully comply with all requirements of this Agreement and the Permit. The Permit will be immediately effective upon issuance for Permit Species currently listed under the ESA. The Permit will become effective for currently unlisted Permit Species upon any future listing of such species under the ESA.
10.2.5 In the event that an additional or amended Section 10 Permit is required for the implementation of any aspect of the Tributary Conservation Plan or Hatchery Compensation Plan, the NMFS shall expedite the processing of such permits or amendments. The Hatchery Permits (direct and incidental) will initially be issued to authorize take through 2013. Beginning in 2013 and every ten (10) years thereafter the District or its agent shall submit to NMFS hatchery permit applications incorporating changes in the hatchery Programs identified in ten (10) year program reviews (See Section 8.8 Program Review).

10.3. Permit Monitoring. Upon issuance of the Permit, the implementation thereof, including each of the terms of this Agreement shall be monitored and evaluated as provided for in Section 4 (Passage Survival Plan). Any reports the FERC should require regarding this Agreement shall be provided to the NMFS at the time such reports are provided to the FERC.

10.4. Permit Modification.

10.4.1 The Permit issued to the District, shall be amended in conformance with the provisions 50 CFR 222.306 (a) (2001) through 222.306 (c) (2001), provided, that if said regulations are modified the modified regulations will apply only to the extent the modifications were required by subsequent action of Congress or court order, unless the Parties otherwise agree.

10.4.2 This Agreement provides for on-going, active and adaptive management activities. Adaptive management provides for on-going modification of management practices to respond to new information and scientific development. Adaptive management will yield prescriptions that may vary over time. Such changes are provided for in this Agreement and do not require modification of the Agreement or amendment of the Permit, provided, that such changes will not result in a level of incidental take in excess of that otherwise allowed by this Agreement and the Permit.

10.5 Permit Suspension, Revocation and Re-Instatement. Except as set forth in sub-Section 2.2.1 (Enough Already), the Permit shall be suspended, revoked and reinstated in conformance with the provisions of 50 CFR 220.306 (d) (2001) and 50 CFR 222.306 (e) (2001), provided, that if said regulations are modified the modified regulations will apply only to the extent the modifications were required by subsequent action of Congress or court order, unless the Parties otherwise agree.
10.6 Early Termination Mitigation. If the Permit is terminated early and de-listing has not occurred, NMFS may require the District to mitigate for any past incidental take of Permit Species that has not been sufficiently mitigated prior to the date of termination. Such mitigation may require the District to continue relevant mitigation Measures of the Agreement for some or all of the period, which would have been covered by the Permit. NMFS agrees that the District may invoke the dispute resolution procedures of this Agreement to pursue resolution of any disagreement concerning the necessity or amount of such additional mitigation, NMFS reserves any authority it may have under the ESA or its regulations regarding additional mitigation. So long as the District meets and continues to meet the pertinent survival standards, its Tributary Plan funding obligations, and its Hatchery Plan funding and capacity obligations, early termination mitigation shall not apply to the District.

10.7 Funding. In its current financial position, the District has sufficient assets to secure funding for its affirmative obligations under the Agreement. To ensure notification of any material change in the financial position of the District during the term of the Permit, the District will provide the NMFS with a copy of its annual report each year of the Permit.

10.8 USFWS. USFWS does not exercise ESA authority over Permit Species.

SECTION 11
DISPUTE RESOLUTION

11.1 Stages of Dispute Resolution.

11.1.1 Stage 1: Coordinating Committee. Any dispute regarding this Agreement shall first be referred to the respective committee dealing with that issue (the Coordinating Committee is the default committee). That Committee shall have 20 Days within which to resolve the dispute. If at the end of 20 Days there is no resolution, any Party may request that the dispute proceed as provided in sub-Section 11.1.2 (Stage 2: Policy Committee). However, Tributary Committee and Hatchery Committee disputes must first proceed to the Coordinating Committee, before the Policy Committee is utilized to resolve the dispute.

11.1.2 Stage 2: Policy Committee. Following the completion of Stage 1, the chair of the Coordinating Committee or any Party may refer the dispute to the Policy Committee. The chair of the Coordinating Committee shall chair all meetings of the Policy Committee. The chair of the Policy Committee shall provide advanced written notice of all meetings. The Policy Committee shall
have 30 Days, following the referral, to convene and consider the dispute. The notice shall contain an agenda of all matters to be addressed and voted on during the meeting.

Each Party shall designate a policy representative who shall be available to participate on the Policy Committee. Any Party that fails to name a Policy Committee representative or to have its Policy Committee representative participate in the Policy Committee shall waive that Party’s right to object to the resolution of the dispute by the Policy Committee.

Agreements reached in the Policy Committee shall be based upon unanimous agreement of those Parties present in person or by phone for the vote and shall develop its own rules of process, provided, that the Policy Committee shall ensure that all Parties are sent notice of all Policy Committee meetings. Abstention from votes does not prevent a unanimous vote. If a Party or its designated representative cannot be present for an agenda item to be voted upon it must notify the chair of the Coordinating Committee who may delay a vote on the agenda item for up to five business days on specified issues to be addressed in a meeting or conference call scheduled with all interested parties. A Party may invoke this right only once per delayed agenda item.

11.1.3 Options following Stage 2. If there is no resolution of a matter following completion of Stage 1 and 2 of this Procedure, then any Party may pursue any other right that they might otherwise have. The Parties agree that the inability of the Coordinating Committee and Policy Committee to make a decision shall be considered a dispute. The Parties are encouraged to resolve disputes through alternative dispute resolution.

11.2 Implementation of Settlement Dispute. If the Procedure outlined above results in a settlement of the dispute then: (1) the Parties shall implement, consistent with the terms of the settlement, all aspects of the settlement that can lawfully be implemented without FERC approval, or the approval of another federal agency; and (2) where FERC or other federal agency approval is needed before some or all of the settlement can be implemented, all settling Parties shall jointly present the resolution of the dispute to FERC or the appropriate federal agency for approval.

11.3 No Intent to Create Jurisdiction. The Parties agree that this Agreement is not intended to create jurisdiction in any court.
SECTION 12
MISCELLANEOUS

12.1 Conflict Between Agreement and Appendix. In the event of a conflict between this Agreement and an Appendix to this Agreement, this Agreement shall control and the Parties shall cause the Appendix in conflict to be revised accordingly.

12.2 Amendment of Agreement. This Agreement may be amended or modified only with the written consent of the Parties, provided, that Parties who withdraw from the Agreement do not need to, and have no right to approve any amendments or modifications, provided further, that this Agreement provides for on-going, active and adaptive management activities. Adaptive management provides for ongoing modification of management practices to respond to new information and scientific developments. Adaptive management will yield prescriptions that may vary over time. Such changes are provided for in this Agreement and do not require modification of the Agreement or amendment of the Permit, provided that such changes will not result in a level of incidental take in excess of that otherwise allowed by this Agreement, or modify the provisions set out in Section 3 (Survival Standards and Allocation of Responsibility for No Net Impact), further provided, that unless otherwise agreed to by the Parties, NNI applies only to the identified Plan Species on the date this Agreement became effective.

12.3 Notices. Except as set forth in sub-Section 2.3 (Conditions Precedent to Withdrawal) and sub-Section 9.3 (Regulatory Approval Without Change), all written notices to be given pursuant to this Agreement shall be mailed by first-class mail, postage prepaid to each Party. Parties shall inform all Parties by written notice in the event of a change of address. Notices shall be deemed to be given three (3) Days after the date of mailing.

12.4 Waiver of Default. Any waiver at any time by any Party hereto of any right with respect to any other Party with respect to any matter arising in connection with this Agreement shall not be considered a waiver with respect to any subsequent default or matter.
12.5 Integrated Agreement. All previous communications between the Parties, either verbal or written, with reference to the subject matter of this Agreement are superseded by the terms and provisions of this Agreement, and once executed, this Agreement and Appendices (See Section 15, Appendix) shall constitute the entire Agreement between the Parties, provided, that titles to sections and sub-Sections thereof are for the assistance of the reader and are not part of the Agreement.

12.6 Benefit and Assignment. This Agreement shall be binding upon and inure to the benefit of the Parties hereto and their successors and assigns provided, no interest, right, or obligation under this Agreement shall be transferred or assigned by any Party hereto to any other Party or to any third party without the written consent of all other Parties, except by a Party: (1) to any person or entity into which or with which the Party making the assignment or transfer is merged or consolidated or to which such Party transfers substantially all of its assets, (2) to any person or entity that wholly owns, is wholly owned by, or is wholly owned in common with, the Party making the assignment or transfer, provided that, the assignee is bound by the terms of this Agreement and applies for and receives an incidental take permit for listed Plan Species.

12.7 Force Majeure. For purposes of this Agreement, a force majeure is defined as causes beyond the reasonable control of, and without the fault or negligence of, the District or any entity controlled by the District, including its contractors and subcontractors. Economic hardship shall not constitute, force majeure under this Agreement.

In the event that the District is wholly or partially prevented from performing obligations under this Agreement because of a force majeure event, the District shall be excused from whatever performance is affected by such force majeure event to the extent so affected, and such failure to perform shall not be considered a material breach. Nothing in this Section shall be deemed to authorize the District to violate the ESA or render the standards and objectives of this Agreement unobtainable. The suspension of performance shall be no greater in scope and no longer in duration than is required by the force majeure.

The District shall notify the other Parties to this Agreement in writing within seven calendar days after a force majeure event. Such notice shall: identify the event causing the delay or anticipated delay; estimate the anticipated length of delay; state the Measures taken or to be taken to minimize the delay; and estimate the timetable for implementation of the Measures. The District shall have the burden of demonstrating by a preponderance of evidence that delay is warranted by a force majeure.
The District shall use a good faith effort to avoid and mitigate the effects of the delay and remedy its inability to perform. A force majeure event may require use of the adaptive management provisions of this Agreement in remedying the effects of the force majeure event. When there is a delay in performance of a requirement under this Agreement that is attributable to a force majeure, the time period for performance of that requirement shall be reasonably extended as determined by the Coordinating Committee. When the District is able to resume performance of its obligation, the District shall give the other Parties written notice to that effect.

12.8 Appropriations. Implementation of this Agreement by the FP is subject to the availability of appropriated funds. Nothing in this Agreement will be construed by the Parties to require the obligation, appropriation, or expenditure of any money from federal, state or tribal governments. The Parties acknowledge that the FP will not be required under this Agreement to expend any of their appropriated funds unless and until an authorized official of that agency or government affirmatively acts to commit to such expenditures as evidenced in writing.

12.9 Legal Authority. Each Party to this Agreement hereby represents and acknowledges that it has legal authority to execute this Agreement and is fully bound by the terms hereof. NMFS is authorized to enter into this Agreement pursuant to the ESA, the Federal Power Act, the Fish and Wildlife Coordination Act, the Northwest Electric Power Planning and Conservation Act, and the Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act.

12.10 Execution. This Agreement may be executed in counterparts. A copy with all original executed signature pages affixed shall constitute the original Agreement. The date of execution shall be the date of the final Party’s signature. Upon execution of this Agreement by the Parties, this Agreement shall be submitted to the Secretary of the Interior, or her designee, for any approval to the extent required by 25 U.S.C. § 81.

12.11 Indian Tribal Treaty or Reserved Rights. Nothing in this Agreement is intended to nor shall it in any way abridge, limit, diminish, abrogate, adjudicate, or resolve any Indian right reserved or protected in any treaty, executive order, statute or court decree. This sub-Section shall be deemed to modify each and every Section and sub-Section of this Agreement as if it is set out separately in each Section.
12.12 **U.S. v Oregon.** Nothing in this Agreement is intended by the signatories who are parties to the continuing jurisdiction case of **U.S. v Oregon** 302 F. Supp. 899 (D. OR 1969), to change the jurisdiction of that court or their participation there in.

12.13 **No Precedent/Compromise of Disputed Claims.** The conditions described and measures proposed to rectify the issues set forth in this Agreement are fact specific and uniquely tied to the circumstances currently existing at the Wells Project. The Parties agree that the conditions existing here and the proposed actions to deal with them are not intended to in any way establish a precedent or be interpreted as the position of any Party in any proceeding not dealing specifically with the terms of this Agreement. Further, the Parties acknowledge that this Agreement is a compromise of disputed claims for which each Party provided consideration to the other as contemplated under Federal Rule of Evidence 408, and will not be used by any Party in a manner inconsistent with the provisions of Federal Rules of Evidence 408.
SECTION 13
DEFINITIONS

Capitalized terms are defined as follows:

13.1 “Agreement” means this document, figures and Appendix A - B. This Agreement is supported by Supporting Documents A through D but does not incorporate these documents.

13.2 “BAMP” means Supporting Document B “Biological Assessment and Management Plan (BAMP): Mid-Columbia Hatchery Program”.

13.3 “Combined Adult and Juvenile Project Survival” means that 91% of each Plan Species (juvenile and adult combined) survival Project effects when migrating through the Project’s reservoir, Forebay, Dam and Tailrace including direct, indirect, and delayed mortality wherever it may occur and can be measured (as it relates to the Project) given the available mark-recapture technology.

13.4 “Dam” means the concrete structure impounding the Columbia River.

13.5 “Day” is defined by the Federal Rules of Civil Procedure.

13.6 “ESA” means the Endangered Species Act, 16 U.S.C. ss 1531 through 1543, as amended, and it’s implementing regulations.

13.7 “Essential Fish Habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act” means the Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. § 1801 et seq., as amended by the Sustainable Fisheries Act and as may be amended, and its implementing regulations.


13.9 “FERC” means the Federal Energy Regulatory Commission or its successor.

13.11 “Forebay” means the body of water from the Dam face upstream approximately 500 feet.

13.12 “Historic Hydroacoustic and Fyke Netting” refers to the use of the 20-year record (1982-2002) of available hydroacoustic and species composition information collected at the Wells Project, as it relates to the passage of juvenile spring and summer migrants.

13.13 “Juvenile Dam Passage Survival” means that 95% of each juvenile Plan Species over 95% of each species migration survive Projects effects when migrating through the Project’s Forebay, Dam and Tailrace including direct, indirect and delayed mortality wherever it may occur and can be measured (as it relates to the Project), given the available mark-recapture technology.

13.14 “Juvenile Project Survival” refers to the measurement of survival for juvenile Plan Species over 95% of each species migrating from tributary mouths and through the Project’s reservoir, Forebay, Dam and Tailrace including direct, indirect and delayed mortality, wherever it may occur and can be measured (as it relates to the Project) given the available mark-recapture technology.

13.15 “Juvenile Project Survival Standard” refers to a surrogate measurement of the Combined Adult and Juvenile Survival Standard. If Juvenile Project Survival for each Plan Species is measured to be greater than or equal to 93%, then the District will be assigned to Phase III (Standards Achieved). If Juvenile Project Survival is measured at less than 93% but greater than or equal to 91%, then the District will be assigned to Phase III (Provisional Review). If Juvenile Project Survival is measured at less than 91%, then the District will be assigned to Phase II (Interim Tools).

13.16 “Measures” means any action, structure, facility, or program (on-site or off-site) intended to improve the survival of Plan Species, except those prohibited in sub-Section 9.10 (Drawdowns/Dam Removal/Non-Power Operation). Measures do not include fish transportation unless otherwise agreed by the Coordinating Committee.


13.18 “Permit” shall mean permit(s) issued to the District by NMFS pursuant to Section 10 of the ESA to authorize take of Permit Species which may result from the District’s or its agent’s implementation of this Agreement.
13.19 “Permit Species” means all Plan Species except coho salmon \((Onocorhynchus kisutch)\). Permit Species do not include coho salmon \((O. kisutch)\) since wild coho salmon are extirpated from the Mid-Columbia Region and therefore not protected by the ESA.

13.20 “Plan Species” means spring, summer/fall chinook salmon \((Onocorhynchus tshawytscha)\), sockeye salmon \((O. nerka)\), coho salmon \((O. kisutch)\), and steelhead \((O. mykiss)\).

13.21 “Power Purchasers” refers to entities that have executed long-term power sales contracts specifically Puget Sound Energy, Inc., Portland General Electric, PacifiCorp., and Avista Corp.

13.22 “Project” means the Wells Hydroelectric Project owned and operated by Public Utility District No. 1 of Douglas County, Washington pursuant to FERC Project Number 2149. The geographic boundaries of the Project including the reservoir, Forebay, Dam and Tailrace are defined in Exhibit K of the Project’s FERC License.

13.23 “Representative Environmental Conditions” means river flows between the 10% and 90% points on the Flow Duration Curve, as calculated using the best available information on historical average river flow (1929-1978, 1993-2001HydroSim) as measured at the Tailrace of Grand Coulee Dam.

13.24 “Representative Operational Conditions” means normative plant operations at Wells Dam that have and are expected to take place during future outmigrations (e.g. normal bypass, fishway and turbine operations).

13.25 “Spill” means the passage of water through spill gates.

13.26 “TDG” means total dissolved gas.

13.27 “Tailrace” means the body of water from the base of the Dam to a point approximately 1000 feet downstream.

13.28 “Threshold Population” refers to a naturally reproducing population that contains a five-year average of greater than 500 adults as assessed at Wells Dam and is composed of a population that is reproductively isolated from other populations of the same species.
13.29 “Tools” means any action, structure, facility or program (on-site only) at the Project, except those prohibited in sub-Section 9.10 (Drawdowns/Dam Removal/Non-Power Operation) that are intended to improve the survival of Plan Species migrating through the Project. Tools do not include fish transportation unless otherwise agreed by the Coordinating Committee. This term is a sub-set of Measures.

13.30 “Unavoidable Project Mortality” refers to the assumed 9% mortality caused by the Project to Plan Species that is compensated through the tributary and hatchery programs.

13.31 “Unforeseen Circumstance” is defined by 50 CFR 222.102 (2001), and implemented according to 50 CFR 222.307(g) (2001). If these regulations are modified, the modified regulations will apply only to the extent the modifications were required by subsequent action of Congress or court order, unless the Parties otherwise agree.
IN WITNESS WHEREOF, the Parties hereto execute this Agreement as of the date last signed below.

Dated MAY 28, 2002

PUBLIC UTILITY DISTRICT NO. 1 OF DOUGLAS COUNTY, WASHINGTON

By Commissioner

[Signature]

Commissioner

[Signature]

Commissioner

Address for Notice:

Public Utility District No. 1 of Douglas County, Washington
1151 Valley Mall Parkway
East Wenatchee, WA 98802-4497

Attrn: Chief Executive Officer/Manager
Dated 1/9/03

NATIONAL MARINE FISHERIES SERVICE,

By __________________________

Regional Administrator

Director, Northwest Region

Address for Notice:

7603 Sandpoint Way, NE

Bldg C1570, Bldg I

Seattle, WA 98115-0070
Dated 4/10/2002

UNITED STATES FISH AND WILDLIFE SERVICE,

By [Signature]
Deputy Regional Director
(Title)

Address for Notice:
Project Leader
US Fish and Wildlife Service
Eastern Washington Ecological Services
Office
320 C Street NW
P.O. Box 848
Ephrata, WA 98823
Dated 4/2/2012

Washington Department of Fish and Wildlife

By

Dr. Jeffrey P. Koenings

Director

Title

Address for Notice:

Washington Department of Fish & Wildlife

600 Capitol Way North

Olympia, WA 98501-1091
Dated April 4, 2002

CONFEDERATED TRIBES OF
THE COLVILLE RESERVATION

By Colleen J. Cashman
Chair, Colville Business Council
(Title)

Address for Notice:
P.O. Box 852
Nespelle, WA 99155
Dated 3-24-05

CONFEDERATED TRIBES AND BANDS OF
THE YAKAMA INDIAN NATION

By [Signature]
Tribal Council Chairman
>Title

Address for Notice:
P. O. Box 151
Toppenish WA 98948
Dated __________________________

CONFEDERATED TRIBES OF THE
UMATILLA INDIAN RESERVATION

By _______________________________

_______________________
(Title)

Address for Notice:

__________________________________
__________________________________
__________________________________
__________________________________
__________________________________

__________________________________

Wells Agreement
Page  60
Dated __________________________

AMERICAN RIVERS, INC., a Washington
D.C., nonprofit corporation

By ______________________________
                                  ________________
                                  (Title)

Address for Notice:
                                 ____________________________
                                 ____________________________
                                 ____________________________
                                 ____________________________
                                 ____________________________
Dated May 8, 2002

PUGET SOUND ENERGY

By [Signature]

(Title)

Address for Notice:

Mail: P.O. Box 97034 OBC-15
Bellevue, WA 98009-9734

Location: One Bellevue Center Bldg.
411 108th Ave N.E. 15th Floor
Bellevue, WA 98004-5515

Wells Agreement
Page 62
Dated May 7, 2002

PORTLAND GENERAL ELECTRIC

By [Signature]

(Vice President) (Title)

Address for Notice:
121 SW Salmon St
Portland, OR 97204

PGE
Approved By:

<table>
<thead>
<tr>
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</table>
Dated 5/10/02

PACIFICORP

By __________________________

Vice President

(Title)

Address for Notice:

Director, Contract Administration

PacifiCorp

825 NE Multnomah, Suite 600

Portland, OR 97232
Dated April 3, 2002

AVISTA CORPORATION

Lloyd H. Meyers
Vice President, Power Supply

>Title
Address for Notice:

Avista Corporation
1411 East Mission Avenue
P.O. Box 3727
Spokane, WA 99220-3727
Figure 1. Wells HCP Survival Standard Decision Matrix.

- **Can the Combined Adult and Juvenile Survival Standard Be Measured?**
  - **YES**
  - Is 91% Combined Adult and Juvenile Survival Standard Being Achieved?
    - **YES**
      - Phase III (Standard Achieved)
    - **NO**
      - Phase II (Interim Tools)
  - **NO**
  - Is Juvenile Project Survival Greater than or Equal to 93%?
    - **YES**
      - Phase III (Standard Achieved)
    - **NO**
      - Is Survival less than 93% but Greater than or Equal to 91%?
        - **YES**
          - Phase III (Provisional Review)
        - **NO**
          - Phase II (Interim Tools)
  - Can Juvenile Project Survival Be Measured?
    - **YES**
      - Phase III (Provisional Review)
    - **NO**
      - Phase II (Interim Tools)
  - Can Juvenile Dam Passage Survival Be Measured?
    - **YES**
      - Is 95% Juvenile Dam Passage Survival Being Achieved via Calculation?
        - **YES**
          - Phase III (Additional Juvenile Studies)
        - **NO**
          - Phase II (Interim Tools)
    - **NO**
      - Then Calculate Juvenile Dam Passage Survival
Figure 2a. Spring Flow Duration Curve

Flow Duration Curve for Average Apr 16 - May 31 Outflows
at Grand Coulee Dam (cfs) from 1929-1978 & 1983-2001
Figure 2b. Summer Flow Duration Curve

Figure 3. Sockeye Enhancement Decision Tree

2002-2003
Collect Spring Chinook Brood Stock at MFH for production of 225,000 smolts (Species Substitution eliminated after 2003 Brood)

2002-2005
Implement Canadian Flow Management Program for Sockeye Enhancement
Goal of program is 7% Compensation

2005
Document the three-year Average Increase in Sockeye production resulting from Implementation of the Flow Mgt. Program

2005
Flow Mgt. Program Increased Sockeye Production by greater than or equal to 7%

2006
Flow Mgt. Program Increased Sockeye Production by less than 7% but greater than 2%
(e.g., 4% Increase in Production)

2005 -
Continue to Provide Funding for Flow Mgt. Program *

2006 - 2007
Continue to Fund Flow Mgt. Program (e.g. 4%) and if supported by Canadians, construct a Spawning Channel that would increase Sockeye Production by 3%

2007 - 2009
Evaluate Increase in Sockeye Production resulting from Spawning Channel (e.g. 3%)

2007 -
Canadians Do Not Support a Sockeye Spawning Channel
Provide MFH Spring Chinook for Ok. Basin

2009
Sockeye Production Increased by at least 7% through a combination of Flow Mgt. and Spawning Channel

2009
Spawning Channel does not provide sufficient Production to satisfy the Full 7% Compensation
Continue to Fund Flow Mgt. * and Fund Channel only if it can produce at least 2% Compensation Remaining compensation to be provided through MFH Spring Chinook planted in the Ok. Basin

2009
Sockeye Production increased by at least 7% resulting from Operation of the Spawning Channel

2009 -
Continue to Fund Sockeye/Spawning Channel

2007 -
Canadians Do Not Support a Sockeye Spawning Channel
Provide MFH Spring Chinook for Ok. Basin

2005
Flow Mgt. Program Increased Sockeye Production by less than 2%

2006 - 2007
Abandon Flow Mgt. Program
If supported by Canadians, Construct a Spawning Channel that would increase Sockeye Production by 7%

2009
Sockeye Production Increased by at least 7% resulting from Operation of the Spawning Channel

2009
Spawning Channel does not provide sufficient Production to satisfy the Full 7% Compensation
Fund Channel only if it can produce at least 2% Compensation Remaining compensation to be provided through MFH Spring Chinook planted in the Ok. Basin

If the coordinating Committee cannot Unanimously Agree to Substitute the remaining Sockeye Compensation in terms of Spring Chinook, then ->

the District would provide Equivalent Funds, as would be needed to rear the required number of Spring Chinook, toward a Coordinating Committee Approved Sockeye Enhancement Program(s).
Appendix A: Wells Hydroelectric Project, Adult Fish Passage Plan.

**Adult Passage Plan**

Adult passage at Wells Dam was addressed under the project’s FERC license (Project No. 2149). Minor modifications to the FERC fish passage conditions were made during negotiations of the Settlement Agreement. Fishway operations are coordinated with the Fish Passage Center. Changes in operating criteria require unanimous support of the Coordinating Committee including approval by NMFS Hydro Program.

Wells Dam was constructed with two fish ladders. Since 1967, an average of 50,000 adult salmon and steelhead have ascended Wells Dam on their way to spawning grounds above the Dam.

The two fish ladders at Wells Dam are conventional staircase type fish ladders with 73 pools. The ladders are located at the east and west ends of the Dam. The lower 56 pools discharge a constant 48 cfs of water. At each pool, the water drops approximately one foot until this water reaches the tailwater level in the collection gallery. Supplemental water can be added at each inundated pool at the upper end of the collection gallery. The upper pools in the adult fishway, pools 73 - 56, discharge water from one pool to another through fishway weirs. Each weir in the upper portion of the adult fishways contains two orifice openings. These orifices are located one foot from the base of the weir. This design provides a sanctuary pool between each of the upper fishway weirs. From pool 56 downstream to the collection gallery, each fishway weir is designed to operate with 48 cfs of water. The water passes from one weir to the next via a seven foot wide overflow section between pools and through two 18 inch by 15 inch submerged orifices.

To accommodate 10 feet of reservoir drawdown, the drop between the upper 17 pools varies from one foot at full reservoir to six inches during a 10 foot reservoir drawdown. The flow through the upper 17 ladder pools consequently varies from 44 cfs at full reservoir to about 31 cfs at maximum reservoir drawdown. To increase the flow to the 48 cfs required in the lower ladder pools, supplementary water is introduced into Pool No. 56 through a pipeline from the reservoir.

Pool No. 64 of both fishway ladders contains facilities for counting fish. The main features of the counting facility include a counting room, an observation window into the fish ladder, a telescoping gate to guide the fish closer to the observation window, a light panel and a bypass gate to control the flow and velocity past the observation window. Video records of fish passage are collected 24-hours per day starting on May 1 and continue
through November 15. The video are then reviewed and counts of fish by species by ladder are made available on a daily basis through coordination with the Army Corps of Engineers adult fish counting program.

At Pool No. 40, each of the two fish ladders has provisions for sorting and trapping various species of fish. The west ladder sorting facility allows for selected fish to travel through a flume to a holding pond at the Wells Hatchery. The east ladder sorting facility allows for fish to travel to a holding container where they are anesthetized, netted and placed in transportation containers to be moved across the Dam to appropriate hatchery facilities. The fisheries agencies and tribes currently develop species-specific broodstock collection protocols at the beginning of each season. Brood stock presently collected at Wells Dam includes spring and summer chinook and summer steelhead. Brood stock collection protocols are developed by the Washington Department of Fish and Wildlife and are annually submitted to the Wells Coordinating Committee and NMFS Hydro Program for annual approval prior to trapping at the Dam. In addition to brood stock collection, the adult fish traps are occasionally used to collected information from CWT tagged steelhead, collect sockeye scales for stock identification and age analysis and collect adult bull trout, chinook, sockeye and steelhead for radio-tagging.

The 2000-2002 Wells Biological Opinion (Section 10.1.4, page 45) requires that the operation of the Wells ladder traps for the collection of broodstock or other fisheries assessment be limited to a maximum of 16-hours per day for three days per week or as approved by NMFS Hydro Program, Portland, Oregon. The Wells Biological Opinion (Section 10.1.4, page 45) requires that adult trapping facilities be manned whenever the trap is in operation and that the collection of adults from the fishway traps be discontinued whenever river water temperature exceed 69°F. Specific operating criteria for the fish ladder traps can be found below (See: Adult Trap Operating Criteria).

At the bottom of the fish ladder, projecting downstream from the line of the hydrocombine is the portion of the endwall structure that incorporates the functions of fish attraction and collection. Two turbine pumps on each ladder deliver 800 to 2500 cfs (depending upon tailwater elevation) of fish attraction flow to the water supply chamber located immediately adjacent to the collection gallery. Supply chamber water flows into the upper sections of the collection gallery where it is used to maintain an attraction velocity of 2 feet per second; and also into the main collection gallery at the foot of the ladder through diffusion gratings. The total fishway flow from the turbine pump(s) and the 48 cfs coming down the ladder from the forebay is discharged into the tailrace through two fish entrances. Fishway entrances are operated according to hydraulic conditions as
specified in the Wells Settlement Agreement. The specific operating conditions of the ladder are described below (See: Adult Fishway Operating Criteria). Modification to the ladder operating criteria can only take place following approval by the Wells Coordinating Committee.

To reduce the total project passage times of adult fish, the main fishway entrances will be operated at an 8-foot opening. To reduce the incidence of fish falling out of the collection gallery, the side gates to the collection gallery will remain closed during normal fishway operations.

Since July 1970, the ladders have been operated with a 1.5 foot differential maintained by constantly adjusting the output of the fish pumps. Under normal conditions the fish pumps operate automatically to maintain a pre-set differential level between the water supply chamber and the main collection chamber.

Fishways are inspected daily to ensure that debris accumulations are removed, that the automated fishway instruments are calibrated properly and to ensure that lights in the fishway are maintained.

**Adult Fish Ladder Operating Criteria**

**Water Depth Criteria**
The water depth over the weirs of the adult fish ladder will be 1.0 to 1.2 feet.

**Entrance Criteria**
1. Head: 1.5 feet
2. Gate Settings: Main Wing Gate open 8 feet,
   Side Wing Gate closed,
   Side Gate Attraction Jets closed.

**Staff Gauge and Water Level Indicator Criteria**
Staff guage and water level indicators are located and maintained upstream and downstream of the Main Wing Gates and adult fishway exit trashracks. These guages should be clearly visible from a convenient location and they should be clean and readable at all water levels. Manual staff gauge readings should be checked each day to ensure that consistent readings are being displayed within the control room.

**Trashrack Criteria**
Visible buildups of debris will be cleaned immediately from picketed leads near counting stations, and from trashracks at adult fishway exits. The staff gauges located immediately upstream and downstream of the adult fishway exit trashracks should be monitored for water surface differential, which may indicate a buildup of debris on the submerged trashracks. The trashracks will be cleaned immediately if the differential reading is greater than 1.0 foot.
Modification of Adult Passage Facilities
If adult passage studies identify biologically significant delay and/or mortality, the operating criteria described above may be changed or modified following approval of the Coordinating Committee. If changes in the operating criteria do not alleviate the problems, then structural modifications to the adult passage facilities may be required. Provided that any disagreements over the appropriateness of facility modifications of $325,000.00 or less (1988 dollars) may be taken through dispute resolution and any disagreement over the appropriateness of facility modifications of more than $325,000.00 (1988 dollars) is resolved under the FERC Rules of Practice and Procedure.

Adult Trap Operating Criteria
Startup: The adult fish traps are located on each fish ladder at Pool 40. The traps are operated by placing a barrier fence across the entire width of Pool 40. Once the barrier fence is in place, the steep-pass denil, upwelling enclosure and sorting chute jets are turned on.

Fish Sorting: Fish that swim up the denil eventually enter the upwell enclosure. Once inside the upwell enclosure, fish are attracted down the sorting chute by jets of water introduced into the upwell enclosure near the top of the sorting chute. As fish slide down the chute, they are identified and a decision is made to either shunt the fish back into the ladder immediately upstream of the barrier fence, or to retain the fish for brood stock or stock assessment. Excess water introduced into the fish ladder from the trap denil and upwell enclosure can, when necessary, be removed from the fish ladder through a piped diversion located downstream of the trap in Pool 40.

Fish Disposition: At the east ladder trap, fish retained for stock assessment are anesthetized, sampled and re-introduced back into the ladder via a recovery/re-introduction tank that is located upstream of the pool 40 barrier fence. Fish retained for brood stock are anesthetized, marked and placed into hatchery transport vehicles. On the west ladder trap, fish retained for brood stock and for stock assessment are passed into a holding pond at the Wells Fish Hatchery. Fish in the holding pond are sorted by WDFW personnel. Fish retained for brood stock are either retained in the hatchery holding pond or placed into transportation vehicles for distribution to other hatchery facilities. Fish retained for stock assessment purposes are placed into transport vehicles and released upstream of the dam.
Safety Measures: The steep-pass denil has been outfitted with two removable gates. The bottom gate prevent fish from moving into the upwell enclosure when the trap is unattended and the top gate prevents fish in the upwell enclosure from moving down the steep-pass denil. The sorting chute has also been upgraded to include a gate on the upstream end. This gate prevents fish from moving down the sorting chute once sufficient numbers of fish have already been placed in the anesthetic tank. The sorting chute has been modified to include full padding and jets of water to keep it moist and cool. Temperature monitors are deployed in the ladder at pool 40 and in the anesthetic tank to ensure compliance with the Wells 2000 BiOp trapping criteria.

Shut Down – Daily: At the end of each trapping day, the barrier fence is lifted out of the ladder, the steep-pass denil is gated first at the bottom and then at the top, the water to the upwelling enclosure is left on, the sorting chute is locked in the return to ladder direction, the sorting chute water jets are left on, the anesthetic tank is drained away from the ladder and all of the fish in the recovery tank are released back into the fish ladder.

Shut Down – Annual: At the end of the trapping season, all water is turned off, all tanks should be checked for fish and then drained. The upwell enclosure water is turned off last and all remaining fish and water should be drained directly into the fish ladder through the upwell enclosure bypass pipe.

BiOp Conditions: The 2000-2002 Wells Biological Opinion (Wells 2000 BiOp) requires that the operation of the Wells ladder traps be limited to a maximum of 16-hours per day for three days per week. To ensure adherence to this trapping schedule, the District has installed remote monitors on the fishway traps. The fish ladder trap monitors notify District personnel when the trap is in operation. The location and duration of ladder trapping is recorded daily and reviewed weekly with WDFW staff. The Wells 2000 BiOp also requires that the adult trapping facilities be manned whenever the trap is in operation and that the collection of adults from the fishway traps be discontinued whenever river water temperature exceed 69°F. Thermographs have been installed immediately adjacent to the traps to ensure that the temperature criteria is not exceeded during adult trapping.

Annual Meeting: District and WDFW trapping personnel meet annually to review the annual brood collection goals, assessment projects, to review current ladder trapping and operating criteria and to discuss modifications to the trap.
Adult Ladder Dewatering Plan

Stage 1 (Notification): Project personnel requiring access to the submerged portions of the adult fish ladders must contact a District Fish Biologist seven days prior to initiating any temporary or extended dewatering of either of the two fishways at Wells. Emergency ladder dewatering should be coordinated with District Fish Biologists to the maximum extent practical given the extent of the emergency. Ladder dewatering to clean the visitor center and the fish counting windows is not considered an emergency. Notice is required to allow District Biologists time to ensure coordination between the scheduled dewatering event and ongoing efforts to collect brood stock for hatcheries, tag fish for stock assessment studies, coordinate fisheries passage inspections and to monitor fish behavior relative to normal project operations. In addition, due to the presence of three stocks of ESA listed fish (UCR spring chinook, UCR steelhead and Columbia River Bull trout) it is important that dewatering events be coordinated with the appropriate resource agencies responsibility for administering the ESA.

Stage 2 (Equipment Preparation): Once notice has been provided to all appropriate entities and resource agencies (including WFH staff), an agreed to ladder dewatering schedule and fish salvage plan should be discussed and coordinated with all affected departments. District personnel are responsible for gathering and inspecting all necessary equipment required to safely collect, hold, transfer and release adult and juvenile fish salvaged from the dewatered fishways. Equipment required for a successful salvage operation include dip nets, a block seine, waders, rain gear, ropes, two 20 foot extendable ladders, flood lights, head lamps, fish totes and fish transport vehicles. Equipment needed for salvaging fish from the dewatered ladder should be moved to the fish ladder at least one day prior to initiating Stage 5 (Exit Gate Closure).

Stage 3 (Day Prior to Dewatering): The day before a scheduled fish ladder dewatering and salvage operation, project personnel should turn off and bulk head each of the two fish pumps located within the water supply chamber. The collection gallery entrances and the ladder exit orifice gates should be operated at normal levels for the remainder of the day.

Stage 4 (Evening Prior to Dewatering): The evening prior to dewatering the fish ladder, the exit orifice gates should be partially closed to allow less than full orifice flow through each of the weirs located in the upper fishway (Weir 73 – 57). The Pool 56 supplemental water supply valve should be set to the fully open position. These settings should remain in place until Stage 7 (Fish Salvage – Upper Fishway) operations have been completed.
Stage 5 (Exit Gate Closure): On the morning of the scheduled dewatering and salvage operation, the exit orifice gates must be turned off gradually. It should require at least 2 hours to completely close off the exit orifice gates. It is important that a District Fish Biologist and appropriate WFH staff be in close proximity to the upper fishway, with equipment in place, prior to project personnel completely closing off the exit orifice gates.

Stage 6 (Supplemental Water): Once the exit orifice gates are closed, it is important to verify that sufficient supplemental water is being added into the middle fishway at Pool 56. If additional water is required, the control room should be contacted to ensure that the supplemental water supply system is being operated at maximum capacity. If the plant operators cannot provide additional water into Pool 56 via the supplemental water supply system, then the District Fish Biologist and the appropriate plant supervisor should discuss whether it is appropriate to move to Stage 7 (Fish Salvage – Upper Fishway). It may be more appropriate to re-open the exit orifice gate and attempt to fix the problem with the supplemental water supply system prior to proceeding to Stage 7. However, if a determination is made to continue to Stage 7 (Fish Salvage – Upper Fishway) then it is the responsibility of the operators to carefully add additional water into the ladder by opening the exit orifice gate until adequate amounts of water are flowing through the middle ladder. Adding supplemental water through the exit orifice gates should only be used as a last resort as this operation establishes a dangerous work environment for personnel attempting to salvage fish from the upper fishway.

Stage 7 (Fish Salvage – Upper Fishway): Provided that sufficient water exists in the middle fish ladder (below Pool 56) fish salvage operations should proceed as described below. Fish salvage operations should start at Pool 73 and move downstream until the upper fishway is free of fish. Fish found in each sanctuary pool will have to be collected with a dip net and transferred directly into the portable fish totes. The order of priority is to net and transfer ESA listed adults, ESA listed juveniles, anadromous adults, anadromous juveniles and then non-listed resident fish.

Once loaded with fish, the fish totes should be hoisted from the sanctuary pool and deposited into Pool 56. Fish collected from Pool 73 through pool 57 are to be hoisted into Pool 56 where supplemental water has been added to carry fish downstream through the middle and lower fishway and into the collection gallery and tailrace. Once all fish have been salvaged from Pool 73 through 57 and all personnel have been evacuated from the fish ladder, the
operators should be contacted to initiate a Stage 8 (Middle Fishway – Pulsed Flow Operation) as described below.

State 8 (Middle Fishway – Pulsed Flow Operation): In order to move fish from Pool 56 down to the tailrace of the project, the adult fishway should be partially re-watered and then dewatered several times. It may become necessary to pulse water from the exit orifice gates several times. Typically three pulses of water are required to flush fish out of the middle and lower ladder and into the tailrace. Pool 40 is a location where fish frequently become stranded during the pulsed flow operation. A hatchery tanker truck and appropriate fish salvage personnel should be stationed at Pool 40 should fish require transport back to the river. The order of priority for fish collection shall be to net and transfer ESA listed adults, ESA listed juveniles, anadromous adults, anadromous juveniles and then net and transfer non-listed resident fish.

Once the fishway has been cleared of fish, the fish being held in the tanker truck should be released back into the river and the exit orifice gates should be closed. Fish salvaged from the east ladder will be released upstream of the dam and fish salvaged from the west ladder will be released into the tailrace.

Stage 9 (Lower Fishway – Collection Gallery): The lower fishway and collection gallery can only be dewatered following the placement of bulkheads across the entrance gates. The floor of the collection gallery can be up to 40 feet below the surface of the tailrace. Therefore the collection gallery must be dewatered with a sump pump. This operation can take several hours depending upon tailrace elevation and leakage into the collection gallery. Once the collection gallery is within one foot of becoming dry, fish salvage personnel should be hoisted with a crane down into the gallery. Once in the gallery, the fish totes should be filled with water and a seine net deployed upstream of the floor diffuser. Fish on top of the floor diffusers should be netted before the water levels drop to less than 6 inches. Once netted, fish should be placed into the fish totes. Depending upon the number and size of fish captured, the fish totes may need to be lifted out of the collection gallery before all of the fish have been collected. Once the crane has lifted the fish totes onto the deck of the dam, the fish should be placed into either a fish release container (300 gallon) or a hatchery transport truck.

Once the collection gallery has been cleared of stranded fish, the fish being held in the tanker truck will be released into either the forebay or tailrace of the dam.
Appendix B: Wells Project Survival Estimates.

Wells Project Survival Estimates

1998 WELLS SURVIVAL STUDY

The 1998 Survival Study, as described in the 1998 study plan “1998 Wells Dam Pilot Survival Study”, was submitted to the WCC for review on September 2, 1997. The study plan was discussed during the September 8th and October 16th meetings of the WCC. The Study plan was modified in September 1997 to include several items requested by the WCC. The Study plan was approved during a conference call on October 16th as documented in the Wells Coordinating Committee meeting minutes (97-8). All parties to the Wells Settlement Agreement were contacted and provided unanimous support for the 1998 study.

The study was completed as directed in the study plan and draft results were presented to the WCC as documented in the 98-4, -5, -6, -8 meeting minutes. The Draft report was submitted to the WCC for review and comment on February 12, 1999. No comments were received by the end of the 60-day comment period. The comment period was extended to allow NMFS additional time for review. The comment period was closed following a 90-day review and following a call from Bob Dach (NMFS) indicating that no comments were going to be submitted by NMFS. The final report entitled: “Project Survival Estimates for Yearling Chinook Salmon Migrating through the Wells Hydroelectric Facility, 1998” was completed on May 27, 1999 and was distributed to the WCC on June 7, 1999. Results of the 1998 Survival Study using yearling Chinook indicated that project survival (Mouth of the Methow River to 1000 feet downstream of Wells Dam) was 99.7% ($\hat{S} = 0.015$).

1999 WELLS SURVIVAL STUDY

The 1999 Survival Study, as described in the 1999 study plan “Wells Dam Steelhead Survival Study, 1999”, was distributed prior to the August 12, 1998 meeting of the WCC. The study plan was discussed during the August 12th and September 22nd meetings. The study plan was revised based upon committee input in late September. The modified study plan was re-submitted to the WCC on October 2, 1998. The modified study plan was further discussed at the October 20, 1998 meetings of the WCC. The 1999 Study plan was unanimously approved during a conference call on November 2nd and reaffirmed at the next formal WCC meeting on November 12, 1998 as documented in the Wells Coordinating Committee meeting minutes (98-10, -11). All parties to the Wells Settlement Agreement were contacted and provided unanimous support for the 1999 study.
The study was completed and preliminary results were sent to the WCC on July 13, 1999. These results were formally presented to the WCC at the September 21, 1999 meeting (99-7). The Draft report was submitted to the WCC for review and comment on November 16, 1999. No comments were received by the end of the 60-day comment period. However, comments were received on February 18, 2000 from Steve Smith (NMFS) and all of Steve’s comments were addressed in the final report. Steve Smith’s comments and the authors response to Steve’s comments can be found in the final report in Appendix C. The final report entitled: “Project Survival Estimates for Yearling Summer Steelhead Migrating through the Wells Hydroelectric Facility, 1999” was completed on March 9, 2000 and was distributed to the WCC on March 24, 2000. Results of the 1999 Survival Study using yearling summer steelhead indicated that project survival (Mouth of the Methow River to 1000 feet downstream of Wells Dam) was 94.3% ($SE = 0.016$).

### 2000 Wells Survival Study

The 2000 Survival Study, as described in the 2000 study plan “Wells Dam Steelhead Survival Study, 2000”, was distributed to the WCC on September 21, 1999 (99-7). The study plan was discussed during the September, October and November 1999 meetings of the WCC (99-7, -8, -9). The Study plan was modified prior to the November meeting based upon input from the WCC. The 2000 survival study plan was approved at the November 1999 meeting as documented in the Wells Coordinating Committee meeting minutes (99-9). All parties to the Wells Settlement Agreement were contacted and provided unanimous support for the 2000 study.

The study was completed and preliminary results were presented to the WCC at the September 12, 2000 meeting (00-10). The Draft report was submitted to the WCC for review and comment on November 30, 2000. No comments were received by the end of the 60-day comment period. However, comments were later received from NMFS and these comments were addressed in the final report. NMFS comments and the author’s response to NMFS’s comments can be found in the final report in Appendix E of the final report. The final report entitled: “Project Survival Estimates for Yearling Summer Steelhead Migrating through the Wells Hydroelectric Facility, 2000” was completed on March 23, 2001 and was distributed to the WCC on March 29, 2001. Results of the 2000 Survival Study using yearling summer steelhead indicated that project survival (Mouth of the Methow River to 1000 feet downstream of Wells Dam) was 94.6% ($SE = 0.015$).
SECTION  16
LIST OF SUPPORTING DOCUMENTS


To receive copies of the Supporting Documents please refer to the District’s website, the National Marine Fisheries Service website or contact the District directly as indicated below.

www.douglas pud.org

www.nwr.noaa.gov/1hydrop/hydroweb/ferchcps.html

Public Utility District No. 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, WA 98802-4497
(509) 884-7191
APPENDIX B

MONITORING & EVALUATION PLAN FOR PUD HATCHERY PROGRAMS: 2013 UPDATE (HILLMAN et al., 2013)
MONITORING AND EVALUATION
PLAN FOR PUD HATCHERY
PROGRAMS

2013 Update

April 17, 2013

Prepared by (alphabetically):
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Keely Murdoch
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Prepared for:
HCP and PRCC Hatchery Committees
Monitoring and Evaluation Plan for PUD Hatchery Programs

This document is a revision of the monitoring and evaluation (M&E) plan of the salmon and steelhead hatchery programs funded by Douglas, Chelan, and Grant County Public Utility Districts (PUDs; see Table 4). Several programmatic changes, evaluation of data collection methods, and M&E results from the past five years, along with shifting management paradigms affect M&E needs, all of which have occurred under advancing fish culture and monitoring techniques. As required by the programs, this document is a result of a five-year review intended to expand on and coalesce previous M&E documents (BAMP 1998; Cates et al. 2005; Murdoch and Peven 2005; Hays et al. 2006; Pearsons and Langshaw 2009a, 2009b) with inclusion of new information.

Fishery management agencies developed the following general goal statements for hatchery programs, which were adopted by the HCP Hatchery Committees and PRCC Hatchery Sub-Committee (hereafter, Hatchery Committees):

1. Support the recovery of ESA-listed species by increasing the abundance of the natural adult population, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity.

2. Increase the abundance of the natural adult population of unlisted plan species, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity. In addition, provide harvest opportunities in years when spawning escapement is sufficient to support harvest.

3. Provide salmon for harvest and increase harvest opportunities, while segregating returning adults from natural tributary spawning populations.

Following the development of Hatchery and Genetic Management Plans (HGMPs), artificial supplementation programs are now characterized into three categories. The first type, integrated conservation programs, are intended to support or restore natural populations. These programs focus on increasing the natural production of targeted fish populations. A fundamental assumption of this strategy is that hatchery fish returning to the spawning grounds are reproductively similar to naturally produced fish. The second type, safety-net programs, are extensions of conservation programs, but are intended to function as reserve capacity for conservation programs in years of low returns. The safety-net provides a demographic and genetic reserve for the natural population. That is, in years of abundant returns they function like segregated programs, and in low return years they can be managed as conservation programs. Lastly harvest augmentation programs are intended to increase harvest opportunities while limiting interactions with wild-origin counterparts.

Monitoring is needed to determine if the hatchery programs are meeting the intended management objectives of conservation, safety-net, or harvest augmentation programs. Objectives for hatchery programs are generally grouped into three categories of performance indicators:
1. In-Hatchery: Is the program meeting the hatchery production objectives?

2. In-Nature: How do fish from the program perform after release?
   a. Conservation Program:
      i. How does the program affect target population abundance and productivity?
      ii. How does the program affect target population long-term fitness?
   b. Safety-Net Program:
      i. How does the program affect target population long-term fitness?
   c. Harvest Augmentation Program:
      i. Does the program provide harvest opportunities?

3. Risk Assessment: Does the program pose risks to other populations?

Objectives in this plan have been organized in a hierarchy where productivity indicators are the primary metrics used to assess if conservation and safety-net program goals have been met; harvest rates and effects on non-targeted populations are used for harvest programs. In cases where productivity indicators are not available or results are equivocal, monitoring indicators may be used to help evaluate the performance of the program. Evaluations of monitoring indicators may not provide sufficiently powerful conclusions on which to base management actions, although they may provide insight as to why a productivity indicator did or did not meet the program goal. Therefore, the relationship between hatchery programs and indicators can be viewed in a chain-of-causation: management actions within the hatchery programs affect the status of monitoring indicators, which in turn influence productivity indicators (Figure 1).

![Diagram of indicator relationship](image)

**Figure 1.** Relationship of indicators to the assessment of supplementation programs. Management actions affect monitoring indicators, which influence productivity indicators. Monitoring indicators may be used to hypothesize the magnitude of influence on productivity.
The primary goal of a conservation program is to contribute to the rebuilding and recovery of naturally reproducing populations within their native habitat. In this plan, natural replacement rates (NRR), recruitment of naturally-produced fish (NOR), and juvenile productivity (juveniles per redd) are important indicators for assessing the success of supplementation. These indicators are difficult to measure precisely and are quite variable in space and time. Therefore, monitoring indicators can be evaluated to help assess if productivity was related to the hatchery programs or other factors (Table 1).

A flow of information following sequential, logical steps will be employed to evaluate supplementation programs, consistent with the indicators described in Table 1. For example, a hatchery program, at a minimum, must be able to produce more adults per spawner than would occur in the natural environment. Should the program fail this test, hatchery operations should be evaluated to determine if improvements can correct the problem. If a program successfully replaces the required number of adults, it is then evaluated against a reference population or condition, if available, to determine if it has increased the overall number of naturally-spawning fish (including both hatchery- and natural-origin adults), increased the number of natural-origin spawners, and to test if productivity of the natural population has changed. When these goals are met, the program is considered successful. When these goals are not met, monitoring indicators may infer why the program is not achieving its goals.

If suitable reference populations are not available, other comparisons can be used to help evaluate treatment responses. Evaluation of programs may pursue the following approaches:

- Comparison to reference population(s) that do not contain pre-treatment data
- Before treatment and after treatment comparisons
- Comparison to standard(s)
- Comparison to other suitable reference conditions

Methodologies for selecting reference streams, analyzing data from treatment and reference stream comparisons, and other comparisons are presented in Hillman et al. (2012).

The primary goals of a safety-net program are to provide demographic and genetic reserves for a population that is supplemented by a conservation program (Table 2). Harvest and adult management may be used to control escapement of spawners when appropriate. Monitoring focuses on estimating the number of fish that escape to spawn naturally and stray rates and in-hatchery performance evaluation.

The primary goal of a harvest augmentation program is to increase harvest opportunities, while segregating adults from natural spawning populations. In this plan, harvest opportunity, survival rates, and stray rates are important indicators for assessing the success of harvest augmentation. These indicators are more readily quantified compared to productivity indicators (Table 2). A flow of information will be employed to evaluate harvest augmentation programs. Since harvest augmentation programs are typically segregated, monitoring indicators will be used to determine the success of a program.
Both monitoring and productivity indicators will be used to evaluate the success of hatchery programs. In the event that the statistical power of tests that involve productivity indicators is insufficient to inform sound management decisions, some of the monitoring indicators may be used to guide management. The overarching goals of conservation, safety-net, and harvest augmentation programs, as described above, are provided below in greater detail. The flow chart (Figure 3) shows the relationship of overarching program goals, the strategies used to meet the goals, the monitoring and evaluation objectives used to evaluate the strategies and determine if goals are being met, and the adaptive management cycle associated with the programs. See Tables 1 and 2 for the indicators under each objective. The logic depicted in this flow chart shall be used to assess M&E results and apply those results to management decisions. Table 4 presents the current hatchery programs releasing fish in the Upper Columbia Basin.

Figure 2. Overview of Monitoring and Evaluation Plan Categories and Components (not including regional objectives).
Table 1. **Program objectives, indicators, and goals for conservation hatchery programs including productivity and monitoring indicators (also applies to safety-net programs when used to support a conservation program).**

<table>
<thead>
<tr>
<th>Objective</th>
<th>Indicator</th>
<th>Target</th>
<th>Rebuild natural populations</th>
<th>Maintain genetic diversity</th>
<th>Opportunity for harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine if the program has increased the number of naturally spawning adults</td>
<td>Abundance of natural spawners</td>
<td>Increase</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult productivity (NRR)</td>
<td>No decrease</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine if the proportion of hatchery fish affects freshwater productivity</td>
<td>Residuals vs. pHOS</td>
<td>No relationship</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Juveniles per redd vs. pHOS</td>
<td>No relationship</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine if run timing and distribution meets objectives</td>
<td>Migration timing</td>
<td>No difference</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spawn timing</td>
<td>No difference</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redd distribution</td>
<td>No difference</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Determine if program has affected genetic diversity and population structure</td>
<td>Allele frequency (hatchery vs. wild)</td>
<td>No difference</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Genetic distance between populations</td>
<td>No difference</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effective population size</td>
<td>Increase</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Age and size at maturity</td>
<td>No difference</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine if hatchery survival meets expectations</td>
<td>HRR</td>
<td>HRR &gt; NRR</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HRR</td>
<td>HRR ≥ Goal</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determine if stray rate of hatchery fish is acceptable</td>
<td>Out of basin</td>
<td>≤ 5%</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Within basin</td>
<td>≤ 10%</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Determine if hatchery fish were released at program targets</td>
<td>Size and number</td>
<td>= Target</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provide harvest opportunities when appropriate</td>
<td>Harvest</td>
<td>Escapement goals</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Program objectives, indicators, and goals for segregated harvest augmentation hatchery programs including monitoring indicators.

<table>
<thead>
<tr>
<th>Monitor indicator</th>
<th>Objective</th>
<th>Indicator</th>
<th>Target</th>
<th>Rebuild natural populations</th>
<th>Maintain genetic diversity</th>
<th>Opportunity for harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rebuild natural populations</td>
<td>HRR &gt; NRR</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Monitoring indicators</td>
<td>Maintain genetic diversity</td>
<td>HRR ≥ Goal</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Monitoring indicators</td>
<td>Opportunity for harvest</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

Table: | Objective | Indicator | Target          |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rebuild natural populations</td>
<td>HRR &gt; NRR</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Maintain genetic diversity</td>
<td>HRR ≥ Goal</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Opportunity for harvest</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Figure 3. Adaptive management flow chart depicting HCP goals, associated strategies to meet the goals, the monitoring and evaluation objectives (indicated in superscript), and the adaptive management feedback cycle. The strategies, objectives, and outcomes are aligned vertically under the corresponding goals.
### Table 3.

Hatchery programs in the mid-Columbia River Basin, 2012. Funding entities included Douglas PUD (D), Chelan PUD (C), Grant PUD (G), Bonneville Power Administration (B), Bureau of Reclamation (O), and Army Corps of Engineers (A) and are listed in order of contribution. Total artificial production targets in the mid-Columbia River exceeds 20 million juveniles annually.

<table>
<thead>
<tr>
<th>Program</th>
<th>Species</th>
<th>Basin</th>
<th>Purpose</th>
<th>Funding Entity</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow</td>
<td>Spring Chinook</td>
<td>Methow</td>
<td>NNI/Conservation</td>
<td>G, C, D</td>
<td>223,765</td>
</tr>
<tr>
<td>Chief Joseph</td>
<td>Spring Chinook</td>
<td>Okanogan</td>
<td>Reintroduction/ Harvest</td>
<td>B, G, C, D</td>
<td>900,000</td>
</tr>
<tr>
<td>Chiwawa</td>
<td>Spring Chinook</td>
<td>Wenatchee</td>
<td>NNI/Conservation</td>
<td>C</td>
<td>144,026</td>
</tr>
<tr>
<td>White</td>
<td>Spring Chinook</td>
<td>Wenatchee</td>
<td>NNI/Conservation</td>
<td>G</td>
<td>74,556</td>
</tr>
<tr>
<td>Nason</td>
<td>Spring Chinook</td>
<td>Wenatchee</td>
<td>NNI/Conservation</td>
<td>G</td>
<td>149,114</td>
</tr>
<tr>
<td>Winthrop</td>
<td>Spring Chinook</td>
<td>Methow</td>
<td>Safety-Net</td>
<td>O</td>
<td>400,000</td>
</tr>
<tr>
<td>Leavenworth</td>
<td>Spring Chinook</td>
<td>Wenatchee</td>
<td>Harvest</td>
<td>O</td>
<td>1,200,000</td>
</tr>
<tr>
<td>Wells</td>
<td>Steelhead</td>
<td>Columbia</td>
<td>Inundation/Safety-Net</td>
<td>D</td>
<td>160,000</td>
</tr>
<tr>
<td>Winthrop</td>
<td>Steelhead</td>
<td>Methow</td>
<td>Conservation</td>
<td>O</td>
<td>100,000-</td>
</tr>
<tr>
<td>Wells</td>
<td>Steelhead</td>
<td>Methow</td>
<td>Inundation/Safety-Net</td>
<td>D</td>
<td>100,000</td>
</tr>
<tr>
<td>Wells/Omak</td>
<td>Steelhead</td>
<td>Okanogan</td>
<td>NNI/Conservation</td>
<td>G</td>
<td>100,000</td>
</tr>
<tr>
<td>Wells</td>
<td>Steelhead</td>
<td>Twisp</td>
<td>Inundation/Conservation</td>
<td>D</td>
<td>40,000</td>
</tr>
<tr>
<td>Wells</td>
<td>Steelhead</td>
<td>Twisp</td>
<td>NNI/Conservation</td>
<td>D</td>
<td>8,000</td>
</tr>
<tr>
<td>Chiwawa</td>
<td>Steelhead</td>
<td>Wenatchee</td>
<td>NNI/Conservation</td>
<td>C</td>
<td>22,000</td>
</tr>
<tr>
<td>Chiwawa</td>
<td>Steelhead</td>
<td>Wenatchee</td>
<td>Inundation/ Harvest</td>
<td>C</td>
<td>165,000</td>
</tr>
<tr>
<td>Chiwawa</td>
<td>Steelhead</td>
<td>Wenatchee</td>
<td>Species trade</td>
<td>C</td>
<td>60,300</td>
</tr>
<tr>
<td>Wells</td>
<td>Summer Chinook</td>
<td>Columbia</td>
<td>Inundation/ Harvest</td>
<td>D</td>
<td>484,000</td>
</tr>
<tr>
<td>Chief Joseph</td>
<td>Summer Chinook</td>
<td>Okanogan</td>
<td>NNI/Cons./Harvest</td>
<td>B, G, C, D</td>
<td>700,000</td>
</tr>
<tr>
<td>Chelan Falls</td>
<td>Summer Chinook</td>
<td>Chelan</td>
<td>Inundation/ Harvest</td>
<td>C</td>
<td>400,000</td>
</tr>
<tr>
<td>Chelan Falls</td>
<td>Summer Chinook</td>
<td>Chelan</td>
<td>NNI/Conservation</td>
<td>C</td>
<td>176,000</td>
</tr>
<tr>
<td>Wells</td>
<td>Summer Chinook</td>
<td>Columbia</td>
<td>Inundation/ Harvest</td>
<td>D</td>
<td>320,000</td>
</tr>
<tr>
<td>Entiat</td>
<td>Summer Chinook</td>
<td>Entiat</td>
<td>Harvest</td>
<td>O</td>
<td>400,000</td>
</tr>
<tr>
<td>Carlton</td>
<td>Summer Chinook</td>
<td>Methow</td>
<td>NNI/Conservation</td>
<td>G</td>
<td>200,000</td>
</tr>
<tr>
<td>Chief Joseph</td>
<td>Summer Chinook</td>
<td>Okanogan</td>
<td>NNI/Cons./Harvest</td>
<td>B, G, C, D</td>
<td>1,300,000</td>
</tr>
<tr>
<td>Dryden</td>
<td>Summer Chinook</td>
<td>Wenatchee</td>
<td>NNI/Conservation</td>
<td>C, G</td>
<td>500,000</td>
</tr>
<tr>
<td>Priest</td>
<td>Fall Chinook</td>
<td>Columbia</td>
<td>Inundation/ Harvest</td>
<td>G</td>
<td>5,000,000</td>
</tr>
<tr>
<td>Priest</td>
<td>Fall Chinook</td>
<td>Columbia</td>
<td>NNI/ Harvest</td>
<td>G</td>
<td>325,543</td>
</tr>
<tr>
<td>Priest</td>
<td>Fall Chinook</td>
<td>Columbia</td>
<td>Fry loss/ Harvest</td>
<td>G</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Priest</td>
<td>Fall Chinook</td>
<td>Columbia</td>
<td>Harvest</td>
<td>A</td>
<td>1,700,000</td>
</tr>
<tr>
<td>Ringgold</td>
<td>Fall Chinook</td>
<td>Columbia</td>
<td>Harvest</td>
<td>A</td>
<td>3,000,000</td>
</tr>
<tr>
<td>Yakama Nation</td>
<td>Coho</td>
<td>Wenatchee</td>
<td>Reintroduction/ Harvest</td>
<td>B, G, C, D</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Yakama Nation</td>
<td>Coho</td>
<td>Methow</td>
<td>Reintroduction/ Harvest</td>
<td>B, G, C, D</td>
<td>500,000</td>
</tr>
<tr>
<td>Skaha</td>
<td>Sockeye</td>
<td>Okanogan</td>
<td>Reintroduction/ Harvest</td>
<td>C, G</td>
<td>≤ 5 M eggs</td>
</tr>
</tbody>
</table>

1 Species listed under the Endangered Species Act.
2 Segregated program.
3 Sub-yearling production.
4 Fry production.
5 Program covered by this M&E Plan.
6 Program also partially covered by CCT M&E Plan.
7 Program affects PUD-funded programs covered by this plan.
8 Planned to increase within the next 5 years.
OBJECTIVES, QUESTIONS, AND HYPOTHESES

Productivity Indicators: Adults

**Objective 1:** Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.

At the core of a conservation program is the objective of increasing the number of spawning adults (i.e., the combined number of naturally produced and hatchery fish) in order to affect a subsequent increase in the number of returning naturally produced fish or natural origin recruits (NOR). In order for the natural population to remain stable or to increase, the Natural Replacement Rate (NRR), or the ratio of NORs to the parent spawning population, must be at a level where parents are being replaced by their offspring as spawners in the next generation. It is possible to affect an increase in natural origin spawners through supplementation with a stable or decreasing NRR. However, if the NRR is below replacement (NRR<1.0), termination of the supplementation program will result in a declining natural population should that state of NRR persist. The proportion of the hatchery-origin spawners (pHOS) that will increase natural production without creating adverse effects to the genetic diversity or reproductive success rate of the natural population is unknown, and may be dependent on how individual hatchery programs are operated, as well as available spawning and rearing habitat. Some programs may restrict pHOS to reduce the risk to the natural population with the intent of optimizing productivity, concomitantly reducing the overall number of spawners. All other objectives of the M&E Plan either directly support this objective or seek to minimize negative effects of the conservation programs on non-target stocks of concern.

Differences in carrying capacities of supplemented and non-supplemented streams can confound the analysis of the effects of supplementation on total number of spawners returning to the streams. For example, if the supplemented population is at carrying capacity and the non-supplemented population is not, the total number of spawners returning to the non-supplemented population may show an increasing trend over time, while the supplemented population would show no increasing trend. To avoid concluding that the supplementation program has no effect or perhaps a negative effect on total spawners, density corrections should be included in the analyses. Hypotheses that may require density corrections are noted under each monitoring question.
1.1 Natural Replacement Rates of Supplemented\(^1\) Populations (*Productivity Indicator*)

**Monitoring Questions:**

Q1.1.1 Has the supplementation program changed the adult productivity (NRRs) of the supplemented populations?\(^2\)

**Target Species/Populations:**

- Q1.1.1 applies to all conservation and safety-net stocks.

**Statistical Hypotheses 1.1.1\(^3\):**

- $H_{0\,1.1.1}$: Slope in NRRs before supplementation $\leq$ slope in NRRs after supplementation.
- $H_{0\,1.1.2}$: Differences in slopes in NRRs between supplemented and reference populations before supplementation $\leq$ differences in slopes in NRRs between supplemented and reference populations after supplementation.
- $H_{0\,1.1.3}$: Mean NRRs before supplementation $\leq$ mean NRRs after supplementation.
- $H_{0\,1.1.4}$: Mean ratio scores in NRRs before supplementation $\leq$ Mean ratio scores in NRRs during supplementation.
- $H_{0\,1.1.5}$: Mean ratio scores in NRRs (adjusted for density dependence) before supplementation $\leq$ Mean ratio scores in NRRs (adjusted for density dependence) during supplementation. [This hypothesis adjusts NRRs for density-dependent effects (see Hillman et al. 2012 for details; Appendix 7).]
- $H_{0\,1.1.6}$: There is no association between the proportion of hatchery-origin spawners (pHOS) and the residuals from the smooth hockey stick stock-recruitment curve; $\rho = 0$. [If there is a significant negative association between pHOS and the residuals, then hatchery fish may be reducing the productivity of the wild population.]

**Measured Variables:**

- Number of hatchery and naturally produced fish on spawning grounds
- Number of naturally produced fish harvested

**Derived Variables:**

- Number of naturally produced recruits by brood year for both naturally produced parents and hatchery parents ($\geq$age-3).
- NRRs (calculated as NORs/spawner).
- Stock-recruit models, parameters, and residuals.
- Includes ratio scores of NRRs (requires reference population[s]).
- Includes calculation of ratios NORs (requires reference population).
- Appendix 1: Spawning escapement and carrying capacity information (as applicable)

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\(^1\) Supplementation programs may include a safety net component.

\(^2\) Because adult productivity is affected by the abundance of the population (i.e., productivity decreases with increasing abundance), the goal of supplementation is to increase or maintain productivity, but not decrease it.

\(^3\) Quality and quantity of data will determine which hypotheses are evaluated. See Hillman et al. 2012 (Appendix 7) for details.
Spatial/Temporal Scale:
- Calculated annually based on brood year.
- Time series.

Possible Statistical Analysis:
- These analyses shall be performed every 5-years. Use graphic analyses, trend analyses, t-tests, Aspin-Welch tests, and randomization tests to evaluate the statistical hypotheses (see Hillman et al. 2012; Appendix 7). The specific analysis used will depend on the availability of reference conditions.
- Correlation analysis will examine associations between hatchery adult composition and NRRs.
- On a five-year period, correlate productivity with extraneous factors such as ocean productivity indices.

Analytical Rules:
- This is a productivity indicator that will be used to assess the success of the supplementation program.
- Type I Error of 0.05.

1.2 Natural Origin Recruits of Supplemented Populations (Productivity Indicator)

Monitoring Questions:
Q1.2.1: Has the supplementation program changed the abundance of NORs within the supplemented population?

Target Species/Populations:
- Q1.2.1 applies to all supplemented or safety net stocks.

Statistical Hypotheses 1.2.1:
- Ho1.2.1.1: Slope in NORs before supplementation ≥ slope in NORs after supplementation.
- Ho1.2.1.2: Differences in slopes in NORs between supplemented and reference populations before supplementation ≥ differences in slopes in NORs between supplemented and reference populations after supplementation.
- Ho1.2.1.3: Mean NORs before supplementation ≥ mean NORs after supplementation.
- Ho1.2.1.4: Mean ratio scores in NORs before supplementation ≥ Mean ratio scores in NORs during supplementation.
- Ho1.2.1.5: Mean ratio scores in NORs/Maximum Recruitment before supplementation ≥ Mean ratio scores in NORs/Maximum Recruitment during supplementation. [This hypothesis adjusts NORs for the capacity of the habitat; it tests the fraction of the habitat saturated with NORs (see Hillman et al. 2012 for details).]

4 Quality and quantity of data will determine which hypotheses are evaluated. See Hillman et al. 2012 (Appendix 7) for details.
5 “Slope in NORS” refers to abundance of NORs across time (years).
• Ho_{1,2,1.6}: There is no association between the proportion of hatchery-origin spawners (pHOS) and NORs; \( \rho = 0 \). [If there is a significant negative association between pHOS and NORs, then hatchery fish may be reducing the reproductive success of the wild population.]

**Measured Variables:**
- Number of hatchery and naturally produced fish on spawning grounds.
- Number of hatchery and naturally produced fish taken for broodstock.
- Number of hatchery and naturally produced fish taken in harvest (if recruitment is to the Columbia).

**Derived Variables:**
- NORs (number of naturally produced recruits (total recruits) by brood year for both naturally produced parents and hatchery parents \([\geq \text{age-3}])\).
- Stock-recruit models, parameters, and residuals.
- Includes ratio scores of NORs (requires reference population[s]).
- Estimates of carrying capacity.

**Spatial/Temporal Scale:**
- Calculate annually based on brood year.
- Time series.

**Possible Statistical Analysis:**
- These analyses shall be performed every 5-years. Use graphic analyses, trend analyses, t-tests, Aspin-Welch tests, and randomization tests to evaluate the statistical hypotheses (see Hillman et al. 2012). The specific analysis used will depend on the availability of reference conditions.
- Correlation analysis will examine associations between hatchery adult composition and NORs.
- On a five-year period, correlate NORs with extraneous factors such as ocean productivity indices.

**Analytical Rules:**
- This is a productivity indicator that will be used to assess the success of the supplementation program.
- Type I Error of 0.05.
Productivity Indicators: Freshwater Environment

**Objective 2:** Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.

Out-of-basin effects (e.g., smolt passage through the hydro system, harvest, and ocean productivity, etc.) influence the survival of smolts after they migrate from the tributaries. These effects introduce substantial variability into the adult-to-adult survival rates (NRRs and HRRs) and may mask in-basin effects (e.g., habitat quality, density-dependent mortality, and differential reproductive success of hatchery and naturally produced fish). Therefore, an estimate of freshwater productivity may help inform the performance of hatchery and natural origin spawners.

The objective of estimating freshwater productivity in the Upper Columbia ESU/DPS is to estimate the survival from egg to a critical juvenile life stage(s) of target stocks. Smolt or juvenile production models generated from the information obtained through these programs will provide a level of predictability with greater sensitivity to in-basin effects than spawner-recruitment models that take into account all effects.

Differences in the current carrying capacities of supplemented and non-supplemented streams can confound the effects of supplementation on numbers of juveniles per redd. For example, if the supplemented population is at or above carrying capacity and the non-supplemented population is not, numbers of juveniles per redd in the non-supplemented population may be significantly greater than the number of juveniles per redd in the supplemented population. In addition, pHOS may be correlated with overall spawner abundance. In these cases, it is difficult or impossible to separate density-dependent effects from the influence of pHOS on freshwater productivity. To avoid concluding that the supplementation program has no effect or perhaps a negative effect on juveniles per redd, the capacity of the habitats must be included in the analyses. The Supplementary Hypotheses presented below are designed to address the confounding effects of different densities on the analyses.

### 2.1 Juvenile Productivity (*Productivity Indicator*)

**Monitoring Questions:**

- **Q2.1.1:** Has the supplementation program changed the number of juveniles (smolts, parr, and/or emigrants) per redd within the supplemented population?
- **Q2.2.1:** Does the number of juveniles per redd decrease as the proportion of hatchery spawners increases?6

**Target Species/Populations:**
- Both Q2.1.1 and Q2.2.1 apply to all conservation stocks.

**Statistical Hypotheses for 2.1.1**7:

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6 Information is needed to estimate the effects of density dependence on these questions. Consider spatial distribution of redds.

7 Information is needed to estimate the effects of density dependence on these questions. Consider spatial distribution of redds.
**MONITORING AND EVALUATION PLAN FOR PUD HATCHERY PROGRAMS**

- **Ho2.1.1.1:** Slope in juveniles/redd before supplementation \( \leq \) slope in juveniles/redd after supplementation.
- **Ho2.1.1.2:** Differences in slopes in juveniles/redd between supplemented and reference populations before supplementation \( \leq \) differences in slopes in juveniles/redd between supplemented and reference populations after supplementation.
- **Ho2.1.1.3:** Mean juveniles/redd before supplementation \( \leq \) mean juveniles/redd after supplementation.
- **Ho2.1.1.4:** Mean ratio scores in juveniles/redd before supplementation \( \leq \) Mean ratio scores in juveniles/redd during supplementation.
- **Ho2.1.1.5:** Mean ratio scores in juveniles/redd (adjusted for density dependence) before supplementation \( \leq \) Mean ratio scores in juveniles/redd (adjusted for density dependence) during supplementation. [This hypothesis adjusts juveniles/redd for density-dependent effects (see Hillman et al. 2012 for details; Appendix 7).]
- **Ho2.1.1.6:** There is no association between the proportion of hatchery-origin spawners (pHOS) and the residuals from the smooth hockey stick stock-recruitment curve; rho = 0. [If there is a significant negative association between pHOS and the residuals, then hatchery fish may be reducing the productivity of the wild population.]

**Statistical Hypotheses for 2.2.1:**
- **Ho2.2.1.1:** There is no association between the proportion of hatchery-origin spawners (pHOS) and the residuals from the smooth hockey stick stock-recruitment curve; rho = 0. [If there is a significant negative association between pHOS and the residuals, then hatchery fish may be reducing the productivity of the wild population.]
- **Ho2.2.1.2:** The slope between proportion of hatchery spawners and juveniles/redd is \( \geq \) 0.

**Measured Variables:**
- Number of hatchery and naturally produced fish on spawning grounds.
- Numbers of redds.
- Number of juveniles (smolts, parr [where appropriate], and emigrants).

**Derived Variables:**
- Number of juveniles per spawner.
- Number of juveniles per redd.
- Carrying capacity.

**Spatial/Temporal Scale:**
- Calculate annually based on brood year.
- Time series.

**Possible Statistical Analysis:**
- These analyses shall be performed every five-years. Use graphic analyses, trend analyses, t-tests, Aspin-Welch tests, and randomization tests to evaluate the statistical

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7 Quality and quantity of data will determine which hypotheses are evaluated. See Hillman et al. 2012 for details.
hypotheses (see Hillman et al. 2012; Appendix 7). The specific analysis used will depend on the availability of reference conditions.

- Correlation analysis will examine associations between hatchery adult composition and juveniles/redd.

**Analytical Rules:**
- This is a productivity indicator that will be used to assess the success of the supplementation program.
- Type I Error of 0.05.
Monitoring Indicators: Natural Environment

**Objective 3:** Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.

The survival advantage from the hatchery (i.e., egg-to-smolt) must be sufficient to produce a greater number of returning adults than if broodstock were left to spawn naturally. If a hatchery program cannot produce a greater number of adults than naturally spawning fish, then the program should be modified or discontinued. Production levels were initially developed using historical run sizes and smolt-to-adult survival rates (BAMP 1998). Using the stock specific NRR and agreed upon target values (e.g. values listed in the BAMP or derived from other sources), comparisons to actual survival rates will be made to ensure the expected level of survival has been achieved.

### 3.1 Hatchery Replacement Rates (HRRs) (*Monitoring Indicator*)

**Monitoring Questions:**
- **Q3.2.1:** Is the adult-to-adult survival rate of hatchery fish (HRR) greater than or equal to the adult-to-adult survival rate (NRR) of naturally produced fish?
- **Q3.2.2:** Is the adult-to-adult survival rate of hatchery fish (HRR) greater than or equal to the Target Value\(^8\)?

**Target Species/Populations:**
- Q3.2.1 applies to all conservation stocks.
- Q3.2.2 applies to all stocks.

**Statistical Hypothesis 3.2.1:**
- \(H_0^{3.2.1.1}: \text{HRR}_{\text{Year }x} \geq \text{NRR}_{\text{Year }x}\)

**Statistical Hypothesis 3.2.2:**
- \(H_0^{3.2.2.1}: \text{HRR} \geq \text{Target Value}\)

**Measured Variables:**
- Number of hatchery and naturally produced fish on spawning grounds.
- Number of hatchery and naturally produced fish harvested.
- Number of hatchery and naturally produced fish collected for broodstock.
- Number of broodstock used by brood year (hatchery and naturally produced fish).

**Derived Variables:**
- Number of hatchery and naturally produced adults by brood year (≥age-3).
- HRR (number of returning adults per brood year/broodstock)
- NRR (from Objective 1)

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\(^8\) Target values may be adjusted by the hatchery committees.
Objective 4: Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.

4.1 Attainment of proportion of hatchery-origin spawners (pHOS or PNI) target (Monitoring Indicator)

Monitoring Questions:
Q4.1.1: Is the estimated proportion of hatchery-origin spawners (pHOS) less than or equal to the management target, and/or, is the estimated Percent Natural Influence (PNI) greater than or equal to the management target?

Target Species/Populations:
- Q4.1.1 applies to all conservation and safety-net stocks that have a defined pHOS or PNI target or sliding scale.

Statistical Hypothesis 4.1.1:
- Ho4.1.1.1: pHOS > target value or PNI_supplemented_population < target value

Measured Variables:
- Number of hatchery and naturally produced fish on spawning grounds

Derived Variables:
- pHOS or PNI
- Appendix 3: PNI and pHOS targets and sliding scales (as applicable)

Spatial/Temporal Scale:
• Calculate annually.
• Analyzed as time series.

**Possible Statistical Analysis:**
• Use graphic analysis and summary statistics to compare pHOS or PNI to the target value.

**Analytical Rules:**
• This is a monitoring indicator that will be used to support management decisions.

**Objective 5:** Determine if the run timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.

Strategies for conservation programs typically intend that hatchery and naturally produced fish spawn together and in similar locations. However, in some cases, strategies may differ from this paradigm (e.g., summer Chinook salmon in the Methow River). Run (migration) timing, spawn timing, and spawning distribution may be affected via phenotypic plasticity or selection resulting from the hatchery environment (i.e., domestication). If conservation programs do not adequately represent the genetic diversity of the natural population, and if phenotypic traits in supplementation fish related to fitness deviate from the naturally produced spawning population, the goals of supplementation may not be achieved. Hatchery adults that migrate and/or spawn at different times or are spatially segregated from naturally produced fish may be subject to reduced fitness. Hatchery adults that spawn at different times or locations than naturally produced fish would be reproductively isolated from the natural population. The extent of such isolation, ranging from no isolation to substantial isolation, may be exploited for management purposes in some cases.

**5.1 Migration Timing (Monitoring Indicator)**

**Monitoring Questions:**
**Q5.1.1:** Is the migration timing of hatchery and naturally produced fish from the same age class similar?

**Target Species/Populations:**
• Q5.1.1 applies to all conservation stocks.

**Statistical Hypotheses 5.1.1:**
• **Ho5.1.1.1:** Migration timing Hatchery Age X = Migration timing Naturally produced Age X
• **Ho5.1.1.2:** The cumulative frequency of migration timing of hatchery-origin fish = the cumulative frequency of migration timing of natural-origin fish.
• **Ho5.1.1.3:** The 10th percentile, 50th percentile (mode), 90th percentile, and mean migration timing of hatchery-origin fish = the 10th percentile, 50th percentile (median), 90th percentile, and mean migration timing of natural-origin fish.
Measured Variables:
- Ages of hatchery and naturally produced fish sampled via pit tags or stock assessment monitoring.
- Time (Julian date) of arrival at mainstem projects and within tributaries (e.g., traps, PIT arrays) with the intent to identify biologically significant differences.

Derived Variables:
- Mean Julian date for a given age class.

Spatial/Temporal Scale:
- Calculate annually based on return year and age class.
- Time series.

Possible Statistical Analysis:
- Use graphic analyses (cumulative frequency polygons), paired t-tests, Aspin-Welch tests, and randomization tests.

Analytical Rules:
- This is a monitoring indicator that will be used to support management decisions.
- Type I Error of 0.05.

5.2 Timing of Spawning (Monitoring Indicator)

Monitoring Questions:
Q5.2.1: Is the timing of spawning similar for conservation hatchery and naturally produced fish?

Target Species/Populations:
- Q5.2.1: Applies to all semelparous species and populations supplemented by conservation programs. Steelhead can only be assessed for natural spawning in situations where hatchery and natural origin fish can be appropriately marked and detected.

Statistical Hypotheses 5.2.1:
- Ho5.2.1.1: The cumulative frequency of spawn timing of hatchery-origin fish = the cumulative frequency of spawn timing of natural-origin fish.
- Ho5.2.1.2: The 10th percentile, 50th percentile (mode), 90th percentile, and mean spawn timing of hatchery-origin fish = the 10th percentile, 50th percentile (mode), 90th percentile, and mean spawn timing of natural-origin fish.

Measured Variables:
- Time (Julian date) of hatchery and naturally produced salmon carcasses or marked steelhead detected on spawning grounds within defined reaches.
- Time (Julian date) of ripeness of hatchery and natural origin steelhead captured for broodstock.
Derived Variables:
- Mean Julian date.

Spatial/Temporal Scale:
- Calculate annually based on return year.
- Time series.

Possible Statistical Analysis:
- Use graphic analyses (cumulative frequency polygons), paired t-tests, Aspin-Welch tests, and randomization tests.
- ANCOVA with elevation as a covariate.

Analytical Rules:
- This is a monitoring indicator that will be used to support management decisions.
- Type I Error of 0.05.

5.3 Spatial Distribution of Redds (Monitoring Indicator)

Monitoring Questions:
- **Q5.3.1:** Is the distribution of redds similar for conservation hatchery and naturally produced fish?
- **Q5.3.2:** Is the distribution of redds similar to defined management targets?

Target Species/Populations:
- **Q5.3.1** applies to all conservation program stocks.
- **Q5.3.2** applies only to conservation program stocks with specific spawning distribution targets (Table 5.3.1).

Statistical Hypothesis 5.3.1:
- **H_{0,5.3.1}**: The distribution of hatchery-origin redds (hatchery females) = the distribution of natural-origin redds (natural-origin females).

Statistical Hypothesis 5.3.2:
- **H_{0,5.3.2}**: The distribution of hatchery-origin redds (hatchery females) = the target distribution identified in Tables 5.3.1.

Measured Variables:
- Location (GPS coordinate) of female salmon carcasses observed on spawning grounds. The distribution of hatchery and naturally produced steelhead redds may be evaluated if marking or tagging efforts provide reasonable results.

Derived Variables:
- Location of female salmon carcass at the historic reach scale and at the 0.1 km scale.
• Calculate percent overlap in distribution across available spawning habitat or historical reaches.
• Appendix 4: Management targets for spatial distribution of spawners or redds (as applicable).

Spatial/Temporal Scale:
• Calculate annually based on return year.
• Time series.

Possible Statistical Analysis:
• Use graphic analysis and Yates’ Chi-square analysis for both Q5.3.1 and Q5.3.2.

Analytical Rules:
• This is a monitoring indicator that will be used to support management decisions.
• Type I Error of 0.05.

Objective 6: Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.

Maintaining locally adapted traits among independent fish populations requires that returning hatchery fish have a high rate of site fidelity to the target stream. Hatchery practices (e.g., imprinting on water source at key life history stages, release methodology, release location, age at return, and environmental conditions) are the main variables thought to affect stray rates. Regardless of the magnitude or homing of adult returns, if adult hatchery fish do not contribute to the natural population the program will not meet the basic condition of a supplementation program. Independent populations are populations that are genetically differentiated from other populations. In some cases, genetic differentiation may be assumed based on phenotypic traits or geographic isolation when molecular genetics analyses are not available. When populations are not independent, straying among them does not pose a risk of genetic homogenization. In addition, stray rates of hatchery-origin fish cannot be expected to be lower than for natural-origin fish. When estimates of stray rates for natural-origin fish are available and if they exceed the 5% or 10% thresholds identified in this plan, analysis and interpretation of stray rates must take into account the concept that hatchery programs may be held to unattainable standards based on the natural stray rate. Current criteria established by the ICBTRT (2005) and the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (2007) indicate that fish that do stray to other non-target populations should not comprise greater than 5% of the non-target spawning population. Likewise, fish that stray into non-target spawning areas within an independent population should not comprise greater than 10% of the non-target spawning aggregate (see Tables 6.1 and 6.2).

6.1.1 Stray Rates among Populations by Brood Return (Monitoring Indicator)

Monitoring Questions:
Q6.1.1: Is the stray rate of hatchery fish less than 5% for the total brood return?
Target Species/Populations:
• Q6.1.1 applies to all hatchery stocks.

Statistical Hypothesis 6.1.1:
• Ho6.1.1.1: Stray rate of hatchery fish ≥ 5% of total hatchery brood return

Measured Variables:
• Number of hatchery carcasses found in non-target and target spawning areas or number of returning spawners counted via PIT-tag detection or at weirs in close temporal proximity to spawning areas.
• Number of hatchery fish collected for broodstock.
• Number of hatchery fish taken in fishery.
• Locations of live and dead strays (used to tease out overshoot).

Derived Variables:
• Total number of hatchery carcasses and take in fishery estimated from expansion analysis.
• Percent of the total brood return that strays.
• Appendix 5: Reciprocal stray rates

Spatial/Temporal Scale:
• Calculate annually based on brood year.
• Time series.

Possible Statistical Analysis:
• Use graphical analysis and one-sample quantile tests to compare the estimated stray rate with the target (5%) stray rate.

Analytical Rules:
• This is a monitoring indicator that will be used to support management decisions.
• Type I Error of 0.05.

6.2 Stray Rates among Populations by Return Year (Monitoring Indicator)

Monitoring Questions:
Q6.2.1: Do hatchery strays make up less than 5% of the spawning escapement within other non-target independent populations?

Target Species/Populations:
• Q6.2.1 applies to all hatchery stocks.
• Ho6.2.1.1: Stray hatchery fish make up ≥ 5% of the spawning escapement (based on run year) within other independent populations

**Measured Variables:**
• Number of hatchery carcasses (PIT-tagged steelhead) found in non-target and target spawning areas or number of returning spawners counted via PIT-tag detection or at weirs in close temporal proximity to spawning areas.

**Derived Variables:**
• Total number of hatchery salmon carcasses (PIT-tagged steelhead, spawners counted at weirs) estimated from expansion analysis.
• Percent of the non-target population that is made up of hatchery strays.
• Appendix 5: Reciprocal stray rates

**Spatial/Temporal Scale:**
• Calculate annually based on return year.
• Time series.

**Possible Statistical Analysis:**
• Use graphical analysis and one-sample quantile tests to compare the estimated stray rate with the target (5%) stray rate.

**Analytical Rules:**
• This is a monitoring indicator that will be used to support management decisions.
• Type I Error of 0.05.

**6.3 Stray Rates among Spawning Areas within the Population (Monitoring Indicator)**

**Monitoring Questions:**
Q6.3.1: Do hatchery strays make up less than 10% of the spawning aggregate within non-target spawning areas within the target population?

**Target Species/Populations:**
• Q6.3.1 applies to all hatchery stocks.

**Statistical Hypothesis 6.3.1:**
• Ho6.3.1: Stray hatchery fish make up ≥ 10% of spawning escapement (based on run year) within non-target spawning areas within the target population

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9 This stray rate is suggested based on a literature review and recommendations by the ICBTRT (2005). It can be re-evaluated as more information on naturally-produced Upper Columbia salmonids becomes available. This will be evaluated on a species and program specific basis and decisions made by the HCP HC. It is important to understand the actual spawner composition of the population to determine the potential effect of straying.

10 The value of 10% should be reviewed by the Hatchery Committee. See footnote 3 for additional information.
Measured Variables:
- Number of hatchery carcasses (possibly PIT-tagged steelhead) found in non-target and target spawning aggregates or number of returning spawners counted via PIT-tag detection or at weirs in close temporal proximity to spawning areas.

Derived Variables:
- Total number of hatchery salmon carcasses (possibly PIT-tagged steelhead or spawners counted at weirs) estimated from expansion analysis.
- Percent of the non-target spawning aggregate that is made up of hatchery strays.
- Appendix 5: Reciprocal stray rates

Spatial/Temporal Scale:
- Calculate annually based on return year.
- Time series.

Possible Statistical Analysis:
- Use graphical analysis and one-sample quantile tests to compare the estimated stray rate with the target (10%) stray rate.

Analytical Rules:
- This is a monitoring indicator that will be used to support management decisions.
- Type I Error of 0.05.
Monitoring Indicators: Population Genetics

**Objective 7:** Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.

The genetic component of the M&E Plan specifically addresses the potential for changes in genetic diversity in natural populations as a result of a hatchery program(s). The long-term fitness of populations is assumed to be related to maintaining the genetic diversity of natural populations. However, hatchery programs select a subset of individuals from the population to pass on genetic material to the next generation. This is often a relatively small number of individuals that produce a large number of offspring, and can result in changes in allele frequencies and reductions of effective population size. Therefore it is important to monitor the genetic status of the natural populations to determine if there are signs of changes in genetic distance among populations, changes in allele frequencies, and to estimate effective population size. Assessing the genetic effects of the hatchery program does not require annual sampling. Meeting stray-rate targets (hypotheses tested under Objective 5) should reduce significant changes in population genetics. Stray rates may inform population genetic analyses. Testing statistical hypotheses associated with genetic components (Hypotheses 3.1, 3.2, and 3.3) should be conducted every ten years or two generations.

7.1 Allele Frequency (*Monitoring Indicator*)

**Monitoring Questions:**

Q7.1.1: Is the allele frequency of hatchery fish similar to the allele frequency of naturally produced and donor fish?

**Target Species/Populations:**

- Q7.1.1 applies to all conservation stocks.

**Statistical Hypotheses 7.1.1:**

- Ho7.1.1: Allele frequency Hatchery = Allele frequency Naturally produced = Allele frequency Donor pop.
- Ha7.1.1: Allele frequency Hatchery ≠ Allele frequency Naturally produced = Allele frequency Donor pop. or
- Ha7.1.1: Allele frequency Hatchery = Allele frequency Naturally produced ≠ Allele frequency Donor pop. or
- Ha7.1.1: Allele frequency Hatchery ≠ Allele frequency Naturally produced ≠ Allele frequency Donor pop.

**Measured Variables:**

- Microsatellite genotypes or SNP genotypes, as appropriate

**Derived Variables:**

- Allele frequency
Spatial/Temporal Scale:
- Analyze as a time series, initially comparing pre- and post-hatchery samples and thereafter every 10 years.
- Compare samples within drainages.

Possible Statistical Analysis:
- Population differentiation tests, analysis of molecular variance (AMOVA), and relative genetic distances.

Analytical Rules:
- This is a monitoring indicator that will be used to support management decisions.
- Type I Error of 0.05.

7.2 Genetic Distances Between Populations (Monitoring Indicator)

Monitoring Questions:
Q7.2.1: Does the genetic distance among subpopulations within a supplemented population remain the same over time?

Target Species/Populations:
- Q7.2.1 applies to all conservation and safety-net stocks.

Statistical Hypothesis 7.2.1:
- Ho_{7.2.1.1}: Genetic distance between subpopulations Year x = Genetic distance between subpopulations Year y

Measured Variables:
- Microsatellite genotypes or SNP genotypes

Derived Variables:
- Allele frequencies

Spatial/Temporal Scale:
- Analyze as a time series, initially comparing pre- and post-hatchery samples and thereafter every 10 years.
- Compare samples among spawning aggregates.

Possible Statistical Analysis:
- Population differentiation tests, AMOVA, and relative genetic distances.

Analytical Rules:
- This is a monitoring indicator that will be used to support management decisions.
- Type I Error of 0.05.
7.3 Effective Spawning Population (*Monitoring Indicator*)

**Monitoring Questions:**
Q7.3.1: Is the ratio of effective population size \(N_e\) to spawning population size \(N\) constant over time?

**Target Species/Populations:**
- Q7.3.1 applies to all supplemented stocks.

**Statistical Hypothesis 3.3:**
- \(H_0\)\_7.3.1.1: \(\frac{N_e}{N}\)\_0 = \(\frac{N_e}{N}\)\_1 for each population

**Measured Variables:**
- Microsatellite genotypes or SNP genotypes

**Derived Variables:**
- Allele frequencies

**Spatial/Temporal Scale:**
- Analyze as a time series, initially comparing pre- and post-hatchery samples and thereafter every 10 years.

**Possible Statistical Analysis:**
- Population differentiation tests, relative genetic distances, statistics to calculate effective population size (e.g., harmonic means).

**Analytical Rules:**
- This is a monitoring indicator that will be used to support management decisions.
- Type I Error of 0.05.
Monitoring Indicators: Phenotypic Traits

Objective 8: Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

Fitness, or the ability of individuals to survive and pass on their genes to the next generation in a given environment, includes genetic, physiological, and behavioral components. Maintaining the long-term fitness of supplemented populations requires a comprehensive evaluation of genetic and phenotypic characteristics. Evaluation of some phenotypic traits (i.e., run timing, spawn timing, spawning location, and stray rates) is addressed under Objective 5. Objective 8 assess the potential effects of domestication, including size at maturity, age at maturity, sex ratio, and fecundity. Age and size at maturity shall be assessed for both fish arriving in the Columbia system, and those recovered on the spawning grounds. Size (or age) selective mortality during migration through the Columbia system, such as through fisheries, could alter the age and size of fish on the spawning grounds.

8.1 Age at Maturity (Monitoring Indicator)

Monitoring Questions:
Q8.1.1: Is the age at maturity of hatchery and naturally produced fish similar at the time they enter the Columbia River and when they spawn?

Target Species/Populations:
• Q8.1.1 applies to all conservation program stocks.

Statistical Hypotheses 8.1.1:
• Ho8.1.1.1: Age at Maturity Hatchery produced spawners Gender X = Age at Maturity Naturally produced spawners Gender X
• Ho8.1.1.2: Age at Maturity All hatchery produced adults Gender X = Age at Maturity All naturally produced adults Gender X

Measured Variables:
• Total and salt (ocean) age of hatchery and naturally produced salmon carcasses collected on spawning grounds.
• Total and salt age of broodstock.
• Total and salt age of fish at stock assessment locations (e.g., Dryden, Tumwater, Wells, Priest Rapids).
• Whenever possible, age at maturity will be measured at weirs or dams near the spawning stream to avoid the size-related carcass recovery bias on spawning grounds (carcass sampling).
• Assess age of fish, including harvested fish.

11 These metrics are difficult to measure, and phenotypic expression of these traits may be all we can measure and evaluate.
Derived Variables:
- Total age and saltwater age
- Age of fish entering the Columbia River.

Spatial/Temporal Scale:
- Calculate annually based on brood year.
- Time series.

Possible Statistical Analysis:
- Use graphic analysis and Yates’ Chi-square.

Analytical Rules:
- This is a monitoring indicator that will be used to support management decisions.
- Type I Error of 0.05.

8.2 Size at Maturity (Monitoring Indicator)

Monitoring Questions:
Q8.2.1: Is the size (length) at maturity of a given age and sex of hatchery fish similar to the size at maturity of a given age and sex of naturally produced fish?

Target Species/Populations:
- Q8.2.1 applies to all conservation and safety-net stocks.

Statistical Hypothesis 8.2.1:
- Ho8.2.1.1: Size (length) at Maturity Hatchery Age X and Gender Y = Size (length) at Maturity Naturally produced Age X and Gender Y
- Ho8.2.1.2: Size (length) at Maturity All hatchery adults Gender X = Size (length) at Maturity All naturally produced adults Gender X

Measured Variables:
- Size (length), age, and gender of hatchery and naturally produced salmon carcasses collected on spawning grounds.
- Size (length), age, and gender of broodstock.
- Size (length), age, and gender of fish at stock assessment locations (e.g., Priest Rapids, Dryden, Tumwater, Wells, Twisp Weir).
- Whenever possible size at maturity will be measured at weirs or dams near the spawning stream to avoid the size-related carcass recovery bias on spawning grounds (carcass sampling).

Derived Variables:
- Total age and saltwater age

Spatial/Temporal Scale:
• Calculate annually based on brood year.
• Time series.

Possible Statistical Analysis:
• Use graphic analysis and three-way ANOVA by origin, gender, and age

Analytical Rules:
• This is a monitoring indicator that will be used to support management decisions.
• Type I Error of 0.05.

8.3 Fecundity at Size (Monitoring Indicator)\textsuperscript{12}

Monitoring Questions:
Q8.3.1: Is the fecundity vs. size relationship of hatchery and naturally produced fish similar?
Q8.3.2: Is the gonadal mass vs. size relationship of hatchery and naturally produced fish similar?

Target Species/Populations:
• Both Q8.3.1 and Q8.3.2 apply to all conservation stocks using both natural- and hatchery-origin broodstock.

Statistical Hypothesis 8.3.1:
• Ho\textsubscript{8.3.1.1}: Slope of Fecundity vs. Size\textsubscript{Hatchery} = Slope of Fecundity vs. Size\textsubscript{Naturally produced}

Statistical Hypothesis 8.3.2:
• Ho\textsubscript{8.3.2.1}: Gonadal Mass vs. Size\textsubscript{Hatchery} = Gonadal Mass vs. Size\textsubscript{Naturally produced}

Measured Variables:
• Length, weight, and age (covariate) of hatchery and natural-origin broodstock after eggs have been removed.
• Number and weight of eggs

Derived Variables:
• Total age and saltwater age.
• Mean weight per egg.

Spatial/Temporal Scale:
• Calculate annually based on brood year.
• Time series.

Possible Statistical Analysis:

\textsuperscript{12} May not apply to all programs.
• Use graphic analysis, regression, t-test, and ANCOVA.

**Analytical Rules:**
• This is a monitoring indicator that will be used to support management decisions.
• Type I Error of 0.05.

**8.4 Sex Ratio (Monitoring Indicator)**

**Monitoring Questions:**
Q8.4.1: Is the sex ratio of hatchery and naturally produced fish similar?

**Target Species/Populations:**
• Q8.4.1 applies to all conservation stocks.

**Statistical Hypothesis 8.4.1:**
• Ho$_{8.4.1}$: Sex Ratio$_{Hatchery} =$ Sex Ratio$_{Naturally produced}$

**Measured Variables:**
• Age and sex of hatchery and naturally produced salmon carcasses collected on spawning grounds or sampled at dams or weirs.
• Whenever possible sex ratio will be measured at weirs or dams near the spawning stream to avoid the size-related carcass recovery bias on spawning grounds (carcass sampling or ultrasound on live fish).

**Derived Variables:**
• Ratio of sexes based on brood year returns

**Spatial/Temporal Scale:**
• Calculate annually based on brood year.
• Time series.

**Possible Statistical Analysis:**
• Use graphic analysis and Yates’Chi-square.

**Analytical Rules:**
• This is a monitoring indicator that will be used to support management decisions.
• Type I Error of 0.05.
Monitoring Indicators: Hatchery Environment

**Objective 9:** Determine if hatchery fish were released at the programmed size and number.

The HCP outlines the number and size of fish that are to be released to meet NNI and inundation compensation levels. The size of the fish at release may be altered according to an adaptive management process in the Hatchery Committee(s), and the number of fish can be altered by survival study results and adjustment of hatchery production for population dynamics. Size of fish at release can affect survival, sex ratios, age at return, stray rate, and fecundity. In addition, the variation in size at release may affect performance of the fish. The coefficient of variation (CV) will be evaluated to ascertain if program performance is related to variation in size at release. Note also that variation in a population is a natural condition and striving to control this variation could result in directional or stabilizing artificial selection that could have unforeseen long-term consequences. Attaining uniform or multi-modal growth in a hatchery environment may not be adaptive for fitness in the wild. Therefore, pursuit of a CV target should be seen as an informative exercise, but is not in itself indicative of success or failure of a hatchery program. Furthermore, growth regimes may prove to be important in affecting adult returns and age structure. Although many factors can influence both the size and number of fish released, past hatchery cultural experience with these stocks should assist in meeting program production levels. Table 9.1 presents the target size at release and CVs for the programs. These targets shall be assessed annually to ensure they are optimized to inform management decisions.

9.1 **Size at Release of Hatchery Fish (Monitoring Indicator)**

**Monitoring Questions:**

**Q9.1.1:** Is the size (length and weight) of hatchery fish released equal to the program goal?

**Target Species/Populations:**

- Q9.1.1 applies to all hatchery stocks.

**Statistical Hypothesis 9.1.1:**

- Ho$_{9.1.1}$: Hatchery fish $\text{Size at release} = \text{Programmed Size at release}$

**Measured Variables:**

- Fork length and weights of random samples of hatchery juveniles at release.

**Derived Variables:**

- Mean length (FL) and mean weight
- Appendix 6: Rearing targets

**Spatial/Temporal Scale:**

- Calculate annually.
- Time series.
Possible Statistical Analysis:
- Use graphic analysis and descriptive statistics to compare the estimated size of hatchery fish at time of release with the program goal.

Analytical Rules:
- This is a monitoring indicator that will be used to support management decisions.

### 9.2 Coefficient of Variation (CV) of Hatchery Fish Released (Monitoring Indicator)

Monitoring Questions:
**Q9.2.1:** Is the CV of hatchery fish released equal to the program target?

Target Species/Populations:
- Q9.2.1 applies to all hatchery stocks.

Statistical Hypothesis 9.2.1:
- Ho$_{9.2.1.1}$: Hatchery fish CV at release = Programmed CV

Measured Variables:
- Length and weights of random samples of hatchery smolts.

Derived Variables:
- Coefficient of Variation: $cv = (1 + 1/4n) \times s/x$ (where $s$ = standard deviation, $x$ = estimated mean, $n$ = sample size)
- Appendix 6: Rearing targets

Spatial/Temporal Scale:
- Calculate annually.
- Time series.

Possible Statistical Analysis:
- Use graphic analysis and descriptive statistics to compare the estimated CV of size of hatchery fish released with the program goal.

Analytical Rules:
- This is a monitoring indicator that will be used to support management decisions.

### 9.3 Condition Factor (K) of Hatchery Fish Released (Monitoring Indicator)

Monitoring Questions:
**Q9.3.1:** Is the K of hatchery fish released equal to the program target?

Target Species/Populations:
- Q9.3.1 applies to all hatchery stocks.
Statistical Hypothesis 9.3.1:
- \( \text{Ho}_{9.3.1.1}: \) Hatchery fish \( K_{\text{at release}} = \text{Programmed } K \)

Measured Variables:
- Monthly individual lengths and weights of random samples of hatchery juveniles.

Derived Variables:
- Condition Factor: \( K = \frac{W}{L^3} \times 10^5 \)

Spatial/Temporal Scale:
- Calculate annually.
- Time series.

Possible Statistical Analysis:
- Use graphic analysis and descriptive statistics to compare the estimated \( K \) of released hatchery fish with the program goal.

Analytical Rules:
- This is a monitoring indicator that will be used to support management decisions.
- Type I Error of 0.05.

9.4 Number of Hatchery Fish (Monitoring Indicator)

Monitoring Questions:
- Q9.4.1: Is the number of hatchery fish released equal to the program goal?

Target Species/Populations:
- Q9.4.1 applies to all hatchery stocks.

Statistical Hypothesis 9.4.1:
- \( \text{Ho}_{9.4.1.1}: \) Hatchery Fish Number = Programmed Number

Measured Variables:
- Numbers of smolts released from the hatchery.

Derived Variables:
- Appendix 6: Rearing targets

Spatial/Temporal Scale:
- Calculate annually.
- Time series.

Possible Statistical Analysis:
• Use graphic analysis and one-sample quantile tests to compare the estimated number of hatchery fish released with the program goal.

Analytical Rules:
• This is a monitoring indicator that will be used to support management decisions.
• Type I Error of 0.05.
Monitoring Indicators: Harvest

Objective 10: Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.

Harvest will be applied to different types of programs in an effort to achieve the management objectives of those programs. Programs designed to augment harvest should routinely contribute to harvest at a rate that greatly reduces the incidence of straying to natural spawning grounds, but also allows the program to be sustained. Safety-net programs may be harvested as part of an adult management strategy to minimize excessive escapement of hatchery-origin fish to spawning grounds. Similarly, conservation programs may undergo harvest to manage returning adults, but the emphasis for these programs should be to achieve escapement goals. In all cases, harvest effort should not have the unintended consequence of removing excessive numbers of conservation or natural-origin fish. In years when the expected returns of hatchery adults are above the level required to meet program goals (i.e., supplementation of spawning populations and/or brood stock requirements), surplus fish may be available for harvest. The M&E Plan specifically addresses harvest and harvest opportunities upstream of Priest Rapids Dam. Harvest or removal of surplus hatchery fish from the spawning grounds may assist in reducing potential adverse ecological and genetic impacts to natural populations (e.g., loss of genetic variation within and between populations, loss of fitness, reduced effective population size, and density-dependent effects).

10.1 Harvest Rates (Monitoring Indicator)

Monitoring Questions:

Q10.1.1: Conservation Programs: Is the harvest on conservation hatchery fish at an appropriate level to manage natural spawning of conservation hatchery fish but low enough to sustain the hatchery program?

Q10.1.2: Safety-Net Programs: Is the harvest on conservation hatchery fish at an appropriate level to manage natural spawning of safety-net hatchery fish but low enough to sustain the hatchery program?

Q10.1.3: Is the harvest on hatchery fish produced from harvest-augmentation programs high enough to manage natural spawning but low enough to sustain the hatchery program?

Q10.1.4: Is the escapement of fish from conservation and safety-net programs in excess of broodstock and natural production\(^\text{13}\) needs to provide opportunities for terminal harvest?

Target Species/Populations:
- Q10.1.1 applies to conservation programs.
- Q10.1.2 applies to safety-net programs.
- Q10.1.3 applies harvest augmentation programs.

\(^\text{13}\) The current best estimates of carrying capacity (maximum recruits) will be used, as available.
• Q10.1.4 applies to conservation and safety-net programs.

**Statistical Hypothesis 10.1.1:**
- Ho10.1.1.1: Harvest rate ≤ Maximum level to meet program goals

**Statistical Hypothesis 10.1.2:**
- Ho10.1.2.1: Harvest rate ≤ Maximum level to meet program goals

**Statistical Hypothesis 10.1.3:**
- Ho10.1.3.1: Escapement ≤ Maximum level to meet supplementation goals

**Statistical Hypothesis 10.1.4:**
- Ho10.1.4.1: Harvest rate ≤ Maximum level to meet program goals

**Measured Variables:**
- Numbers of hatchery fish taken in harvest.
- Numbers of natural-origin fish taken in harvest.

**Derived Variables:**
- Total harvest by fishery estimated from expansion analysis.

**Spatial/Temporal Scale:**
- Calculated annually.
- Time series.

**Possible Statistical Analysis:**
- Use graphic analysis and one-sample quantile tests to compare the estimated harvest of hatchery fish with the program goal.

**Analytical Rules:**
- This is a monitoring indicator that will be used to support management decisions.
- Type I Error of 0.05.
Regional Objectives

Hatchery programs have the potential to increase diseases that typically occur at low levels in the natural environment (Objective 9). In addition, hatchery fish can reduce the abundance, size, or distribution of non-target taxa through ecological interactions (Objective 10). These are important objectives that will be monitored at a later time. Analytical rules will be established for these objectives before monitoring activities begin.

**Objective 11: Determine if the incidence of disease has increased in the natural and hatchery populations.**

The hatchery environment has the potential to amplify diseases that are typically found at low levels in the natural environment. Amplification could occur within the hatchery population (i.e., vertical and horizontal transmission) or indirectly from the hatchery effluent or commingling between infected and non-infected fish (i.e., horizontal transmission). Potential impacts to natural populations have not been extensively studied, but should be considered for programs in which the hatchery fish are expected to commingle with natural fish. This is particularly important for supplementation type programs. Specifically, the causative agent of bacterial kidney disease (BKD), *Renibacterium salmoninarum* (Rs), could be monitored at selected acclimation ponds, both in the water and fish, in which the risk and potential for transmission from the hatchery is highest. Although it is technologically possible to measure the amount of Rs in water or Rs DNA in smolts and adults non-lethally sampled, the biological meaning of these data are uncertain. Currently, the only metric available for M & E purposes is measuring the antigen level from kidney/spleen samples (i.e., ELISA, PCR). When available, non-lethal sampling may replace or be used in concert with lethal sampling.

Implementation of this objective will be conducted in a coordinated approach within the hatchery and natural environment. BKD management within the hatchery population (e.g., broodstock or juveniles) has the potential to reduce the prevalence of disease through various actions (e.g., culling or reduced rearing densities). BKD management must also take into account and support other relevant objectives of the M & E program (e.g., Hatchery Return Rate [HRR], number of smolts released). Hence, the goal of BKD management is to decrease the prevalence of disease and maintain hatchery production objectives (i.e., number and HRR).

As previously discussed, disease transmission from hatchery to naturally produced fish may occur at various life stages and locations. Of these, horizontal transmission from hatchery effluent, vertical transmission on the spawning grounds, and horizontal transmission in the migration corridor have been identified as disease interactions that could be examined under this objective, although others may also be relevant. Experimental designs addressing this objective may require technology not yet available, although in some instances samples may be collected, but not analyzed until a link can be established between bacteria levels in samples and disease prevalence.
Developing a complete set of questions and hypotheses statements for this objective may not be practical at this time, because there is currently no BKD Management Plan. However, while developing experimental designs for this objective, it may be feasible to incorporate both hatchery and natural environment monitoring under a single study design. Integration of the different aspects of the objective would likely result in a more robust approach into understanding the effectiveness of disease management strategies.

**Proposed Tasks:**

**T1:** Assemble fish health data for fish used as brood (e.g., ELISA results).

**T2:** Conduct data exploration exercise to identify potential relationships between pathogen profiles and likely causative variables (e.g., rearing conditions and management actions).

**T3:** Develop hypotheses for potential testing to meet objective.

**Objective 12: Determine if the release of hatchery fish affects non-target taxa of concern (NTTOC) within acceptable limits.**

Ecological risks of Pacific salmon (spring, summer, and fall run Chinook, coho, and sockeye salmon) and steelhead trout hatchery programs operated between 2013 and 2023 in the Upper Columbia Watershed will be assessed using Delphi and modeling approaches. Committees composed of resource managers and public utility districts identified non-target taxa of concern (i.e., taxa that are not the target of supplementation), and acceptable hatchery impacts (i.e., change in population status) to those taxa. Biologists assembled information about hatchery programs, non-target taxa, and ecological interactions and this information will be provided to expert panelists in the Delphi process to facilitate assessment of risks and also used to populate the Predation, Competition, and Disease (PCD) Risk 1 model. Delphi panelists will independently estimate the proportion of a non-target taxa population that will be affected by each individual hatchery program. Estimates from each of the two approaches will be independently averaged, a measure of dispersion calculated (e.g., standard deviation), and subsequently compared to the acceptable hatchery impact levels that were determined previously by committees of resource managers and public utility districts. Measures of dispersion will be used to estimate the scientific uncertainty associated with risk estimates. Delphi and model results will be compared to evaluate the qualities of the two approaches. Furthermore, estimates of impacts from each hatchery program will be combined together to generate an estimate of cumulative impact to each non-target taxa.

The Hatchery Evaluation Technical Team (HETT) is currently addressing this objective. Work has been underway for several years. The study is expected to provide risk assessment using both an ecological modeling approach and a panel of expert opinion. These two methods will be compared to establish the potential to use modeling in place of expert panels to conduct such risk assessments in the future.
Adaptively Managing Using Monitoring and Evaluation Results

Because of naturally large variation in productivity indicators, several years of data may be required before statistical inferences can be made regarding the effects of hatchery fish on productivity of naturally produced fish. Furthermore, given the large natural variation of productivity indicators, productivity could increase or decrease as a result of the hatchery programs before a difference is detected statistically. In the interim, risk associated with supplementation programs and the productivity of naturally produced fish can be quantified based on observed natural variation in the indicator of interest (Table 1). If large differences in rates of change between supplemented and reference populations are observed, management actions may be required.

Assuming hatchery programs do not negatively affect the productivity of naturally produced fish, the observed difference in rates of change between the supplemented and reference populations should decrease over time as more of the natural variation within and between populations is incorporated into these data. More simply, as the number of years increases, the acceptable observed difference in the indicator(s) decreases. The value of the difference at any point in time would determine if management actions are warranted.
References


# Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult-to-Adult survival (Ratio)</td>
<td>The number of parent broodstock relative to the number of returning adults.</td>
</tr>
<tr>
<td>Age at maturity</td>
<td>The age of fish at the time of spawning (hatchery or naturally)</td>
</tr>
<tr>
<td>Augmentation</td>
<td>A hatchery strategy where fish are released for the sole purpose of providing harvest opportunities.</td>
</tr>
<tr>
<td>Broodstock</td>
<td>Adult salmon and steelhead collected for hatchery fish egg harvest and fertilization.</td>
</tr>
<tr>
<td>Donor population</td>
<td>The source population for supplementation programs before hatchery fish spawned naturally.</td>
</tr>
<tr>
<td>Effective population size (Ne)</td>
<td>The number of reproducing individuals in an ideal population (i.e., Ne = N) that would lose genetic variation due to genetic drift or inbreeding at the same rate as the number of reproducing adults in the real population under consideration (Hallerman 2003).</td>
</tr>
<tr>
<td>ESA</td>
<td>Endangered Species Act passed in 1973. The ESA-listed species refers to fish species added to the ESA list of endangered or threatened species and are covered by the ESA.</td>
</tr>
<tr>
<td>Expected value</td>
<td>A number of smolts or adults derived from survival rates agreed to in the Biological Assessment and Management Plan (BAMP 1998).</td>
</tr>
<tr>
<td>Extraction rate</td>
<td>The proportion of the spawning population collected for broodstock.</td>
</tr>
<tr>
<td>Genetic diversity</td>
<td>All the genetic variation within a species of interest, including both within and between population components.</td>
</tr>
<tr>
<td>Genetic stock structure</td>
<td>A type of assortative mating, in which the gene pool of a species is composed of a group of subpopulations, or stocks, that mate panmictically within themselves.</td>
</tr>
<tr>
<td>Genetic variation</td>
<td>All the variation due to different alleles and genes in an individual, population, or species.</td>
</tr>
<tr>
<td>HCP</td>
<td>Habitat Conservation Plan is a plan that enables an individual or organization to obtain a Section 10 Permit which outlines what will be done to “minimize and mitigate” the impact of the permitted take on a listed species.</td>
</tr>
<tr>
<td>HCP-HC</td>
<td>Habitat Conservation Plan Hatchery Committee is the committee that directs actions under the hatchery program section of the HCP’s for Chelan and Douglas PUDs.</td>
</tr>
<tr>
<td>HRR</td>
<td>Hatchery Replacement Rate is the ratio of the number of returning hatchery adults relative to the number of adults taken as broodstock, both hatchery and naturally produced fish (i.e., adult-to-adult replacement rate).</td>
</tr>
<tr>
<td>Long-term fitness</td>
<td>Long-term fitness is the ability of a population to self-perpetuate over successive generation.</td>
</tr>
<tr>
<td>Naturally produced</td>
<td>Progeny of fish that spawned in the natural environment, regardless of the origin of the parents.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td><strong>Mean Ratio</strong></td>
<td>The ratio between a treatment and control population, with the mean taken across a time period, such as years. Used in analysis in Before-After-Control-Impact studies.</td>
</tr>
<tr>
<td><strong>Ne</strong></td>
<td>Effective population size</td>
</tr>
<tr>
<td><strong>Non-target taxa of concern (NTTOC)</strong></td>
<td>Species, stocks, or components of a stock with high value (e.g., stewardship or utilization) that may suffer negative impacts as a result of a hatchery program.</td>
</tr>
<tr>
<td><strong>NRR</strong></td>
<td>Natural replacement rate is the ratio of the number of returning naturally produced adults relative to the number of adults that naturally spawned, both hatchery and naturally produced.</td>
</tr>
<tr>
<td><strong>NTTOC</strong></td>
<td>Non-target taxa of concern.</td>
</tr>
<tr>
<td><strong>pHOS</strong></td>
<td>Proportion of Hatchery Origin Spawners</td>
</tr>
<tr>
<td><strong>PNI</strong></td>
<td>Proportionate Natural Influence</td>
</tr>
<tr>
<td><strong>pNOB</strong></td>
<td>Proportion of Natural Origin Broodstock</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td>The capacity in which juvenile fish or adults can be produced.</td>
</tr>
<tr>
<td><strong>Reference population</strong></td>
<td>A population in which no directed artificial propagation is currently directed, although may have occurred in the past. Reference populations are used to monitor the natural variability in survival rates and out of basin impacts on survival.</td>
</tr>
<tr>
<td><strong>SAR</strong></td>
<td>Smolt-to-adult survival rate</td>
</tr>
<tr>
<td><strong>SAR Smolt-to-adult survival rate (SAR)</strong></td>
<td>Smolt-to-adult survival rate is a measure of the number of adults that return from a given smolt population.</td>
</tr>
<tr>
<td><strong>Segregated</strong></td>
<td>A type of hatchery program in which returning adults are spatially or temporally isolated from other populations.</td>
</tr>
<tr>
<td><strong>Size-at-maturity</strong></td>
<td>The length or weight of a fish at a point in time during the year in which spawning will occur.</td>
</tr>
<tr>
<td><strong>Smolts per redd</strong></td>
<td>The total number of smolts produced from a stream divided by the total number of redds from which they were produced.</td>
</tr>
<tr>
<td><strong>Spawning Escapement</strong></td>
<td>The number of adult fish that survive to spawn.</td>
</tr>
<tr>
<td><strong>Stray rate</strong></td>
<td>The rate at which fish spawn outside of natal rivers or the stream in which they were released.</td>
</tr>
<tr>
<td><strong>Supplementation</strong></td>
<td>A hatchery strategy where the main purpose is to increase the relative abundance of natural spawning fish without reducing the long-term fitness of the population.</td>
</tr>
<tr>
<td><strong>Target population</strong></td>
<td>A specific population in which management actions are directed (e.g., artificial propagation, harvest, or conservation).</td>
</tr>
</tbody>
</table>
Appendices

**Appendix 1:** Spawning escapement objectives for steelhead, spring- and summer-Chinook in the mid-Columbia River.

**Appendix 2:** HRR Targets

**Appendix 3:** PNI and pHOS Management Targets or Sliding Scales.

**Appendix 4:** Management Targets for the Spatial Distribution of Spawners or Redds.

**Appendix 5:** Reciprocal stray rate objectives for UCR summer steelhead and spring Chinook.

**Appendix 6:** Rearing Targets for PUD-Funded Hatchery Programs.
Appendix 7:

Methods for Identifying Reference Populations and Testing Differences in Abundance and Productivity between Reference Populations and Supplemented Populations:

Chiwawa Spring Chinook Case Study

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A. Murdoch
T. Pearsons
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G. Mackey

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An important goal of supplementation is to increase spawning abundance and natural-origin recruitment of the supplemented population, and not reduce the productivity of the supplemented population. Indeed, a successful supplementation program must increase spawning abundance and natural-origin recruitment to levels above those that would have occurred without supplementation. There are several methods that can be used to test the effects of supplementation programs on these population metrics. One important method is to compare the performance of population metrics (e.g., spawning abundance, natural-origin recruitment, and productivity) in the supplemented population to those in un-supplemented (reference) populations. By comparing supplemented populations to reference populations, one can determine if the supplementation programs benefit, harm, or have no effect on the supplemented populations. These comparisons, however, are only valid if the performance of the reference populations is similar to the performance of the supplemented population prior to the period of supplementation. If the performance of the two populations differs significantly before any supplementation occurs, then any results from comparing the two populations after supplementation will be suspect. It is therefore important to select reference populations that are as similar as possible to the supplemented populations.

One of the goals of the Conceptual Approach to Monitoring and Evaluating the Chelan County PUD Hatchery Programs (Murdoch and Peven 2005) is to use reference populations to analyze the potential effects of hatchery supplementation programs on natural-origin salmon and steelhead spawner abundance and productivity. Murdoch and Peven (2005) identified specific objectives to evaluate the performance of the program. For example, Objective 1 determines if the supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population (supplemented population) relative to a reference population. Objective 7 determines if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (e.g., number of juveniles per redd) of supplemented streams when compared to reference streams. The relevant questions tested under each objective are as follows:

14 Productivity is defined as adult recruits per spawner, where recruits are the number of adults produced from a given brood year (i.e., spawners plus adults harvested).
Objective 1:

- Is the annual change in the number of natural-origin recruits produced from the supplemented populations greater than or equal to the annual change in natural-origin recruits in an un-supplemented population?
- Is the change in natural replacement rates within the supplemented population greater than or equal to the change in natural replacement rates in an un-supplemented population?

Objective 7:

- Is the change in numbers of juveniles (smolts, parr, or emigrants) per redd in the supplemented population greater than or equal to that in an un-supplemented population?\(^{15}\)

In this paper, we describe methods used to identify suitable reference streams and statistical techniques that can be used to compare reference populations with supplemented populations. Although we apply the methods described in this paper to Chiwawa spring Chinook salmon (hereafter referred to as Chinook), the methods should also apply to steelhead and other supplemented salmon stocks in the Upper Columbia Basin.

**Identification of Reference Populations**

Reference populations are an important component of an effectiveness monitoring design because they provide the standard by which treatment conditions are compared (ISRP and ISAB 2005; Murdoch and Peven 2005; Galbreath et al. 2008). Selecting appropriate reference areas and maintaining them over long periods of time is needed to establish the effectiveness of supplementation programs.

We developed a three-step process for identifying suitable reference populations (Figure 1). Each step serves as a filter. That is, potential reference populations are evaluated based on specific criteria under each step. Populations that pass through each step are considered suitable reference populations for a specific supplemented population.

\(^{15}\) In this paper we only address adult recruits, not juvenile recruits. This is because we were unable to find suitable reference populations for analysis of juveniles. However, the methods described in this paper would also apply to juveniles.
Figure 1. Criteria evaluated during each step in the process of identifying suitable reference populations.

**Step 1: General Characteristics**

Under step 1, potential reference populations are evaluated based on several general criteria. When compared to the supplemented population, potential reference populations should have:

- Similar life-history characteristics (e.g., run timing, migration characteristics, etc.).
- No or few hatchery fish in the reference area (pHOS < 10%).
- Accurate abundance estimates.
- Long time series of natural-origin abundance and productivity estimates (at least 20 years of continuous data).
- Similar trends in freshwater habitat.
- Similar out-of-basin effects (i.e., similar migration and ocean survivals).
- Harvest estimates for adjusting escapement estimates.

We used these criteria to begin the process of selecting suitable reference populations for the Chiwawa spring Chinook program. We began by identifying stream-type Chinook populations within the Columbia Basin. Galbreath et al. (2008; their Table 1) identified stream-type Chinook populations within the Columbia River Basin that may serve as suitable reference populations for hatchery programs. Supplementing their work with data from the NOAA Fisheries Salmon Population Summary Database, we identified 18 candidate stream-type Chinook populations that may serve as reference populations for the Chiwawa supplementation program (Table 1).
Table 1. Populations of stream-type Chinook salmon and their comparison to Chiwawa spring Chinook.

<table>
<thead>
<tr>
<th>Population</th>
<th>Similar life-history</th>
<th>No or few hatchery fish</th>
<th>Accurate abundance estimates</th>
<th>Long time series (at least 20 years)</th>
<th>Similar freshwater habitat impairments</th>
<th>Similar out-of-basin effects</th>
<th>Comments</th>
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<tr>
<td>Deschutes River</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>John Day mainstem</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Middle Fk John Day</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td></td>
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<tr>
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<td>Yes</td>
<td>Yes</td>
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<td></td>
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<tr>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Hatchery strays (&gt;10%)</td>
</tr>
<tr>
<td>Wenaha River</td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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</tr>
<tr>
<td>Minam River</td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Slate Creek</td>
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<td>Yes</td>
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<td>No</td>
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<tr>
<td>Seccesh River</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Fair productivity est.</td>
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<tr>
<td>Big Creek</td>
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<td>Yes</td>
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<td></td>
</tr>
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<td>Camas Creek</td>
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</tr>
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<td>Yes</td>
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<td></td>
</tr>
<tr>
<td>Bear Valley Creek</td>
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<td>Yes</td>
<td>Yes</td>
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<td>No</td>
<td></td>
</tr>
<tr>
<td>Marsh Creek</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>North Fk Salmon River</td>
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<td>No</td>
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<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Hatchery strays (&gt;10%)</td>
</tr>
<tr>
<td>Lemhi River</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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</tr>
<tr>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
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</tr>
<tr>
<td>Valley Creek</td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Chamberlain Creek</td>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
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</tr>
<tr>
<td>Naches River</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Hatchery strays (&gt;10%)</td>
</tr>
<tr>
<td>Little Wenatchee River</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Hatchery release ending</td>
</tr>
<tr>
<td>Entiat River</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Hatchery release ending</td>
</tr>
</tbody>
</table>

We then assessed the accuracy and length of the series of abundance estimates. We assumed that abundance estimates generated from expanded redd counts or adjusted weir counts would compare well with estimates in the Chiwawa Basin, which were based on expanded redd counts. In addition, we looked for populations that had an abundance data series that extended from at least 1981 to present. Based on this analysis, we identified 18 populations with abundance estimates that could be compared to those from the Chiwawa Basin (Table 1).

Next, we determined if the potential reference populations came from watersheds with habitat conditions similar to those in the Chiwawa Basin. For this exercise, we searched recovery plans and draft recovery plans to identify tributary factors that limit Chinook abundance, productivity, and survival within the reference populations. We compared these factors with those limiting
Chinook salmon in the Chiwawa Basin. Based on this analysis, we identified eight populations with habitat impairments similar to those in the Chiwawa Basin (Table 1).

Finally, we examined the potential reference populations to see if they experienced out-of-basin effects similar to spring Chinook from the Chiwawa Basin. In this case, we compared the number of mainstem dams that each potential reference population passes during migration. Six of the potential reference populations pass less than six mainstem dams; the other populations pass eight mainstem dams (Table 1). Only the Little Wenatchee population passes seven dams, similar to the Chiwawa population.

In sum, there were no reference populations that matched the Chiwawa spring Chinook population on all the criteria identified above. Differential out-of-basin effects and freshwater habitat conditions prevented most reference populations from matching with Chiwawa spring Chinook. However, some of the potential reference populations were similar to the Chiwawa population on several criteria and warranted further investigation. We selected the following populations for further investigation: Sesech River, Marsh Creek, Naches River, Little Wenatchee, and Entiat River.

We included the Little Wenatchee because it is within the Wenatchee River basin and experiences similar out-of-basin effects and has the same climatic and environmental conditions as the Chiwawa. A confounding effect with the Little Wenatchee is that Chiwawa hatchery fish have strayed into the Little Wenatchee. However, straying of Chiwawa hatchery fish should decrease with the change in source water to the Chiwawa acclimation ponds in 2006. We also included the Entiat River because it is an adjacent basin to the Chiwawa and experiences similar climatic and environmental conditions. The spring Chinook hatchery program that has operated in the Entiat since 1975 has been discontinued. Therefore, this population offers a unique opportunity to compare the Chiwawa population to a population in which the hatchery program has been discontinued.

**Step 2: Graphic and Statistical Analysis**

*Graphic Analysis*

Although we were unable to find potential reference populations that matched with the Chiwawa population on all criteria considered under Step 1, spawner abundance, natural-origin recruits (NORs), and productivity of some of the potential reference populations may nevertheless track closely with the Chiwawa population. If the time series of abundance, NORs, and productivity of a potential reference population tracks closely with the abundance, NORs, and productivity of the Chiwawa population, the reference population may provide a reasonable reference condition for testing the effects of supplementation on the Chiwawa population.

Under Step 2, we used graphing techniques to examine the relationship of abundance, NORs, and productivity between the Chiwawa population and the five reference populations (Sesech River, Marsh Creek, Naches River, Little Wenatchee, and Entiat River). We compiled spawner abundance, NORs, and productivity data from local biologists and the NOAA Fisheries Salmon Population Summary Database. We then compared time series plots of spawner abundance, NORs, and productivity data of potential reference populations with the Chiwawa population (Figures 2, 3, and 4; plots on the left side of figures). The time series only included the period 1981 to 1992, which represented the period before supplementation of the Chiwawa population (pre-treatment period). We also plotted the relationship between the abundance, NORs, and
productivity of each potential reference population to the Chiwawa population (Figures 2, 3, and 4; plots on right side of figures). These plots show whether the reference populations closely tracked the Chiwawa population. As a point of reference, data points that fall along the dashed line would represent a perfect relationship between the two populations (i.e., both populations have identical abundance, NORs, and productivity estimates). While a perfect relationship between two independent populations is unrealistic, a strong linear relationship between the two populations indicates populations with similar trends.

Based on analysis of spawner abundance, the Naches River time series tracked more closely with the abundance of Chiwawa spring Chinook than did the other potential reference populations. The poor relationship with the other potential reference streams was largely because of the relatively high abundance of Chiwawa spring Chinook during the mid-1980s. As with spawner abundance, analyses of NORs indicated a close relationship between the Naches and Chiwawa populations. The other potential reference populations tracked poorly with the Chiwawa. The analyses of productivity indicated close relationships between potential reference populations and the Chiwawa population. The Naches, Sesech, and Little Wenatchee populations tracked the closest with the Chiwawa population.

When analyzing the potential effects of a supplementation program on fish performance, it is common to transform the data to meet various assumptions of statistical analysis. The most common transformation used to adjust abundance, NORs, and productivity data is the natural logarithm (LN or loge). We therefore transformed the spawner abundance, NORs, and productivity data using LN and re-plotted the relationships between the potential reference populations and the Chiwawa population (Figures 5, 6, and 7). We added 1 to each observation before taking its logarithm to avoid taking the logarithm of 0, which is undefined (note that the LN of 1 is 0).

By transforming spawner abundance, NORs, and productivity data, most of the potential reference populations tracked more closely with the Chiwawa population. The Naches, Entiat, and Little Wenatchee abundance data tracked the closest with the Chiwawa abundance data (Figure 5). For NORs, Marsh Creek and the Little Wenatchee populations tracked the closest with the Chiwawa (Figure 6). For productivity, the Naches, Sesech, and Little Wenatchee tracked the closest with the Chiwawa (Figure 7).
Figure 2. Time series of spawner abundance of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.
Figure 3. Time series of natural-origin recruits (NORs) of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.
Figure 4. Time series of adult productivity of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.
Figure 5. Time series of natural log spawner abundance of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.
Figure 6. Time series of natural log natural-origin recruits (NORs) of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.
Figure 7. Time series of natural log adult productivity of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.
Correlations and Trends

Other methods for evaluating the suitability of potential reference populations under Step 2 include correlation and trend analyses. For correlation analysis, we simply calculated the Pearson correlation coefficient, which is an index of the strength of the association between the potential reference populations and the Chiwawa population. The coefficient ranges from -1 to 1, where a value near 1 or -1 represents that strongest association between the populations. A value of 0 means no association. We used only spawner abundance, NORs, and productivity data during the pre-treatment period (1981-1992). We assumed that populations with coefficients greater than 0.6 represented reasonable reference conditions.

For trend analyses, we used least squares techniques to compute a straight-line trend through the spawner abundance and productivity data for the potential reference populations and the Chiwawa population. Trends were fit to the pre-treatment time series data (1981-1992). We then used t-tests to determine if the slopes of the trends between potential reference populations and the Chiwawa population differed significantly.

It is important to note that time-series trend analyses are susceptible to temporal correlations in the data. Autoregressive integrated moving average (ARIMA) models can be used to describe the correlation structure in temporal data (Gotelli and Ellison 2004). However, these models require a long time series (N > 40) and therefore we could not use them to model the spring Chinook data. As such, we were unable to correct for any temporal correlation that may exist within the time series.

Tests of correlation with spawner abundance data indicated that the Naches River closely correlated with the Chiwawa population (Table 2). There was no difference in abundance trends between the potential reference populations and the Chiwawa population (Table 2; Figure 2). For NORs, all potential reference populations correlated with the Chiwawa population (Table 2). However, trends in NORs of all reference populations, except Naches, differed significantly from the Chiwawa population (Table 2; Figure 3). For productivity, the Naches, Sesech, and Little Wenatchee correlated with the Chiwawa population (Table 2). Only the Entiat productivity trend differed significantly from the Chiwawa population trend (Table 2; Figure 4).

Table 2. Pearson correlation coefficients and t-test results comparing slopes of trends between potential reference populations and the Chiwawa spring Chinook population; d.f. = degrees of freedom and for correlation coefficients, an asterisk (*) indicates significance at P < 0.05.

<table>
<thead>
<tr>
<th>Reference populations</th>
<th>Pearson correlation coefficient</th>
<th>t-test on slopes</th>
<th>t-value</th>
<th>d.f.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Spawner Abundance Data</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.684*</td>
<td>-0.659</td>
<td>8</td>
<td>0.528</td>
<td></td>
</tr>
<tr>
<td>Entiat</td>
<td>0.598*</td>
<td>-0.596</td>
<td>18</td>
<td>0.559</td>
<td></td>
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<tr>
<td>Marsh</td>
<td>0.147</td>
<td>-1.341</td>
<td>18</td>
<td>0.197</td>
<td></td>
</tr>
<tr>
<td>Sesech</td>
<td>0.274</td>
<td>-1.265</td>
<td>18</td>
<td>0.222</td>
<td></td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.399</td>
<td>-0.591</td>
<td>18</td>
<td>0.562</td>
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</tr>
<tr>
<td><strong>Natural-Origin Recruits</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.803*</td>
<td>0.666</td>
<td>8</td>
<td>0.524</td>
<td></td>
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<tr>
<td>Entiat</td>
<td>0.795*</td>
<td>-7.495</td>
<td>18</td>
<td>0.000</td>
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</tbody>
</table>
We also ran correlation and trend analyses on natural-log transformed spawner abundance, NORs, and productivity data. These analyses indicated that the Naches, Entiat, and Little Wenatchee abundance data correlated with the Chiwawa population data (Table 3). None of the abundance trends of the potential reference populations differed significantly from the Chiwawa population trend (Table 3; Figure 5). For NORs, all potential reference populations correlated with the Chiwawa population (Table 3). Only trends in NORs of the Entiat and Sesech differed significantly from the Chiwawa population (Table 2; Figure 6). For productivity, the Naches, Marsh, Sesech, and Little Wenatchee correlated with the Chiwawa population data (Table 3). Only the Entiat productivity trend differed significantly from the Chiwawa population trend (Table 3; Figure 7).

Table 3. Pearson correlation coefficients and t-test results comparing slopes of trends between potential reference populations and the Chiwawa spring Chinook population; d.f. = degrees of freedom and for correlation coefficients, an asterisk (*) indicates significance at P < 0.05. Analyses were conducted on natural-log transformed abundance and productivity data.

<table>
<thead>
<tr>
<th>Reference populations</th>
<th>Pearson correlation coefficient</th>
<th>t-test on slopes</th>
<th></th>
<th></th>
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<tr>
<td></td>
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<td>d.f.</td>
<td>P-value</td>
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<td><strong>LN Spawner Abundance Data</strong></td>
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<td>0.642*</td>
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<tr>
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<td></td>
<td></td>
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<td>d.f.</td>
<td>P-value</td>
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<td>Little Wenatchee</td>
<td>0.862*</td>
<td>-1.811</td>
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In summary, based on correlation, trend, and graphic analyses, the Naches, Entiat, and Little Wenatchee populations appear to be reasonable reference populations for comparing spawner abundance data with Chiwawa data. For NORs, the Naches, Marsh, and Little Wenatchee appear to be reasonable reference populations. For productivity, the Naches, Marsh, Sesech, and Little Wenatchee populations appear to be reasonable reference populations for the Chiwawa population.

**Minimal Detectable Differences (MDD)**

Given a suite of potential reference populations, it is important to conduct power analyses to determine the minimum differences that can be detected when comparing the reference populations to the supplemented population. As a final exercise under Step 2, we examined potential reference populations for the smallest minimal detectable differences. Before conducting power analyses, several decisions needed to be made, including what statistical procedures will be used to analyze the data, the desired level of statistical power (probability of rejecting a false null hypothesis), the size of the type-I error (the probability of rejecting a true null hypothesis of no difference), and the number of samples (i.e., years) included in the analysis. In this case, the number of samples represents the number of treatment (supplementation) years. The number of pre-treatment years (1981-1992) was based on the number of years of quality data available for Chiwawa spring Chinook and potential reference populations.

We designed the study as a modified BACI (Before-After, Control-Impact) design, which includes replication before and after supplementation in both the treated (T) population and the reference (R) populations. A common approach used to analyze data from BACI designs includes analysis of difference scores (Stewart-Oaten et al. 1992; Smith et al. 1993). Differences are calculated between paired treatment and reference population scores (i.e., T-R). Another approach is to calculate ratios (treatment/reference; T/R) for paired treatment and reference population scores (Skalski and Robson 1992). Finally, differences in annual changes in paired treatment and reference population scores can be calculated (i.e., ΔT-ΔR) (Murdoch and Peven 2005; Hays et al. 2006). These derived difference and ratio scores are then analyzed for a before-after treatment effect with a two-sample t-test, Aspin-Welch modification of the t-test, or a randomization test. For power analyses, we calculated minimal detectable differences assuming the difference of annual difference scores was estimated by first subtracting the population parameter (e.g., spawner abundance) in year 2 from year 1. This continues for all years in the data series for both treatment (T_{t+1} - T_t) and reference populations (R_{t+1} - R_t). We then calculated differences between paired treatment and reference annual difference scores [(T_{t+1} - T_t) - (R_{t+1} - R_t) = ΔT-ΔR].

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16 The difference of annual difference scores was estimated by first subtracting the population parameter (e.g., spawner abundance) in year 2 from year 1. This continues for all years in the data series for both treatment (T_{t+1} - T_t) and reference populations (R_{t+1} - R_t). We then calculated differences between paired treatment and reference annual difference scores [(T_{t+1} - T_t) - (R_{t+1} - R_t) = ΔT-ΔR].
the use of an independent two-sample t-test with a type-I error rate of 0.05, power of 0.80 (beta or type-II error rate of 0.20), and sample sizes (treatment years) of 5, 10, 15, 20, 25, and 50 years.

The power analysis calculated the minimal detectable difference between mean difference or ratio scores before and during supplementation. We used existing data to calculate variances for the pre-supplementation and supplementation periods. Thus, variances were known and unequal. For both spawner abundance and NORs, the null hypothesis tested was that the mean difference or ratio before supplementation equaled the mean difference or ratio during supplementation. The alternative hypothesis was that the mean difference or ratio before supplementation was less than the mean difference during supplementation (one-tail test; Difference < 0). For productivity, the null hypothesis tested was that the mean difference or ratio before supplementation equaled the mean difference or ratio during supplementation. The alternative hypothesis was that the mean difference or ratio before supplementation was greater than the mean difference during supplementation (one-tail test; Difference > 0).

Based on spawner abundance data, power analysis indicated that the Sesech-Chiwawa pairing consistently produced the smallest detectable differences (Table 4). However, when the abundance data were transformed using natural logs, the Entiat-Chiwawa pairing produced the smallest detectable difference (Table 5). Minimal detectable differences, based on mean difference scores on untransformed data and a treatment period of 20 years, ranged from 334 to 394 adult spawners; transformed data ranged from 0.479 to 1.010. These analyses indicate that the Naches, Entiat, Sesech, and Little Wenatchee populations appear to be reasonable reference populations for comparing spawner abundance data with Chiwawa data. The Marsh Creek population produced some of the largest detectable differences and based on these analyses may not be a reasonable reference population.

Table 4. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on spawner abundance data.

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Treatment years</th>
<th>Minimal detectable differences by reference population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Naches</td>
<td>Entiat</td>
</tr>
<tr>
<td>T-R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>638</td>
<td>604</td>
</tr>
<tr>
<td>10</td>
<td>464</td>
<td>448</td>
</tr>
<tr>
<td>15</td>
<td>405</td>
<td>395</td>
</tr>
<tr>
<td>20</td>
<td>376</td>
<td>368</td>
</tr>
<tr>
<td>25</td>
<td>358</td>
<td>352</td>
</tr>
<tr>
<td>50</td>
<td>322</td>
<td>319</td>
</tr>
<tr>
<td>T/R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.600</td>
<td>2.084</td>
</tr>
<tr>
<td>10</td>
<td>0.506</td>
<td>1.548</td>
</tr>
<tr>
<td>15</td>
<td>0.478</td>
<td>1.367</td>
</tr>
<tr>
<td>20</td>
<td>0.465</td>
<td>1.275</td>
</tr>
<tr>
<td>25</td>
<td>0.458</td>
<td>1.219</td>
</tr>
<tr>
<td>50</td>
<td>0.447</td>
<td>1.105</td>
</tr>
<tr>
<td>ΔT-ΔR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1,049</td>
<td>761</td>
</tr>
</tbody>
</table>
### Table 5.

Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on natural-log transformed spawner abundance data.

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Treatment years</th>
<th>Minimal detectable differences by reference population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Naches</td>
</tr>
<tr>
<td>T-R</td>
<td>5</td>
<td>0.975</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.721</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0.637</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.595</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>0.569</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.521</td>
</tr>
<tr>
<td>T/R</td>
<td>5</td>
<td>0.157</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.116</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0.102</td>
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<tr>
<td></td>
<td>20</td>
<td>0.095</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>0.091</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.082</td>
</tr>
<tr>
<td>ΔT-ΔR</td>
<td>5</td>
<td>1.261</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.898</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0.776</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.713</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>0.675</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.600</td>
</tr>
</tbody>
</table>

Based on NORs, power analysis indicated that the Entiat-Chiwawa, Marsh-Chiwawa, and Little Wenatchee-Chiwawa pairings produced the smallest detectable differences (Table 6). When NORs were transformed using natural logs, the Little Wenatchee-Chiwawa pairing produced the smallest detectable difference (Table 7). Minimal detectable differences, based on mean difference scores on untransformed data and a treatment period of 20 years, ranged from 483 to 640 NORs; transformed data ranged from 0.958 to 2.262. These analyses indicate that the Entiat, Marsh, and Little Wenatchee populations appear to be reasonable reference populations for comparing NORs with Chiwawa data.
### Table 6. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on natural-origin recruits.

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Treatment years</th>
<th>Minimal detectable differences by reference population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Naches</td>
</tr>
<tr>
<td>T-R</td>
<td>5</td>
<td>1,139</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>809</td>
</tr>
<tr>
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<td>698</td>
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<td>640</td>
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<td></td>
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<td>604</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>534</td>
</tr>
<tr>
<td>T/R</td>
<td>5</td>
<td>0.469</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.451</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0.446</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.445</td>
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<tr>
<td></td>
<td>25</td>
<td>0.444</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.443</td>
</tr>
<tr>
<td>ΔT-ΔR</td>
<td>5</td>
<td>1,639</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1,239</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>1,109</td>
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<td>20</td>
<td>1,046</td>
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<td>25</td>
<td>1,009</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>943</td>
</tr>
</tbody>
</table>

### Table 7. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on natural-log transformed natural-origin recruits.

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Treatment years</th>
<th>Minimal detectable differences by reference population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Naches</td>
</tr>
<tr>
<td>T-R</td>
<td>5</td>
<td>2.380</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>2.291</td>
</tr>
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<td>15</td>
<td>2.270</td>
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<td>20</td>
<td>2.262</td>
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<td>2.258</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>2.253</td>
</tr>
<tr>
<td>T/R</td>
<td>5</td>
<td>0.322</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.301</td>
</tr>
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<td></td>
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<td>0.294</td>
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<tr>
<td></td>
<td>25</td>
<td>0.293</td>
</tr>
</tbody>
</table>
Using untransformed productivity data, power analysis indicated that the Little Wenatchee-Chiwawa pairing consistently produced the smallest detectable differences (Table 8). The Marsh-Chiwawa pairings produced the largest detectable differences. When we analyzed natural-log transformed productivity data, the Naches-Chiwawa and Little Wenatchee-Chiwawa pairings produced the smallest detectable differences (Table 9). Minimal detectable differences, based on mean difference scores on untransformed data and a treatment period of 20 years, ranged from 0.754 to 1.839; transformed data ranged from 0.277 to 0.477. These analyses indicate that the Naches, Entiat, Sesech, and Little Wenatchee populations appear to be reasonable reference populations for comparing productivity data with Chiwawa data. The Marsh Creek population produced some of the largest detectable differences and based on these analyses may not be a reasonable reference population.

**Table 8.** Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on productivity data.
Table 9. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on natural-log transformed productivity data.

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Treatment years</th>
<th>Minimal detectable differences by reference population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Naches</td>
<td>Entiat</td>
</tr>
<tr>
<td>T-R</td>
<td>5</td>
<td>0.540</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.367</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0.308</td>
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<td></td>
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<td>0.257</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.215</td>
</tr>
<tr>
<td>T/R</td>
<td>5</td>
<td>0.915</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.744</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0.691</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.666</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>0.652</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.628</td>
</tr>
<tr>
<td>ΔT-ΔR</td>
<td>5</td>
<td>0.885</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.631</td>
</tr>
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<td>0.546</td>
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<td>0.502</td>
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<td></td>
<td>25</td>
<td>0.475</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.423</td>
</tr>
</tbody>
</table>

Step 3: Quantitative Method for Ranking Selection Criteria

Not surprisingly, different selection criteria produced different results (Table 10). Determining whether a given population is or is not a suitable reference population based on selection criteria such as graphic analysis can be subjective. In addition, treating each selection criterion as equally important may not be appropriate. For example, using the information in Table 10, is it appropriate to select a reference population that has two or three “Yes” entries, or should only populations with four “Yes” entries be selected as suitable reference populations? This approach does not allow certain selection criteria to carry more weight in the overall selection process.
That is, correlation may be more important than graphic analysis in the overall selection process. In order to reduce subjectivity, we developed a method of scoring and weighting each selection criterion. This method allows a more quantitative process for selecting suitable reference populations.

**Table 10.** Summary of results from graphic analysis, correlations, trend analysis, and power analysis (minimal detectable differences). “Yes” indicates that the population is a suitable reference population for the Chiwawa population; “No” indicates that it may not be a suitable reference population.

<table>
<thead>
<tr>
<th>Potential reference populations</th>
<th>Graphic analysis</th>
<th>Correlation</th>
<th>Trends</th>
<th>Minimal detectable differences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spawner Abundance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Entiat</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Marsh</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sesech</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Natural-Origin Recruits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Entiat</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Marsh</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sesech</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Entiat</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Marsh</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sesech</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

We developed scoring methods for each of the following five selection criteria:

1. The proportion of natural-origin spawners (pNOS) in the reference population for the period before supplementation (pre-pNOS);
2. pNOS in the reference population for the period following supplementation (post-pNOS);
3. The correlation between the reference and supplemented populations before supplementation;
4. The relative difference in slopes between the reference and supplemented populations before supplementation; and
5. The coefficient of variation (CV) of the ratio of supplemented to reference populations before the period of supplementation.

Each selection criteria was scored from 0 to 1, with 0 being the worst possible score and 1 being the best.
The pre- and post-pNOS values were calculated as the average pNOS values before and after supplementation, respectively. Because pNOS values range from 0-1, we did not need to rescale these values. When using reference populations to evaluate the effects of supplementation programs, it is important that the reference populations maintain high values of pNOS throughout the life of the monitoring program. Therefore, we heavily weighted the mean pNOS scores. We assigned weights of 30 and 40 to the mean pre- and post-pNOS scores, respectively. The relatively larger weight for the post-supplementation period is to reduce the likelihood of retaining a reference population that becomes influenced by hatchery fish during the supplementation period.

We assessed the association between the reference and supplemented populations during the pre-supplementation period by calculating the Pearson correlation coefficient, which ranges from -1 to 1. To scale the coefficient between 0 and 1, we took the absolute value of the coefficient. Thus, a coefficient of -0.92 would be reported as 0.92. For our analyses, we were not concerned with the direction of the relationship, only the strength of the relationship. The correlation coefficient was given a weight of 12.5.

As noted earlier, we used least squares to fit a linear trend to each of the reference populations and the supplemented population during the pre-supplementation period. Using the slope estimates for each trend line, we calculated the relative difference in slopes as the slope of the supplemented population minus the slope of the reference population, divided by the slope of the reference population. To scale this value between 0 and 1, we used absolute values, and depending on the direction of the slopes, we subtracted the relative difference from 1. The latter was needed to make sure a larger relative difference value indicated a small difference in slopes between the supplemented and reference populations. The relative difference score was given a weight of 7.5.

Finally, as a means to score effect size, we calculated the CV of the ratio of supplemented to reference population parameters (i.e., T/R). The CV was calculated as the standard deviation of the ratios divided by the absolute value of the mean ratios. The CV was subtracted from 1. This scaled the value from 0 to 1 with larger values representing the best condition. The CV was given a weight of 10, which is greater than the weight for trend, but less than the weight for correlation.

The total score for a reference population was calculated by multiplying the estimated value, which ranged from 0 to 1, by its weight. The sum of the five weighted values provided a total score, which ranged from 0 to 100. Based on several simulations, we set the cut-off score at 81. That is, if the total score for a given reference population equaled or exceeded 81, the population was included as a suitable reference population. If the total score fell below 81, the population was not considered a suitable reference. Based on the distribution of all scores possible, a score of 81 or greater represented only 3% of the total distribution. Thus, a cut-off of 81 is quite conservative.

Under Step 3, we used this method to select the final suite of suitable reference populations. Table 11 shows results from scoring each of the reference populations using the quantitative method. Using the cut-off criterion of 81, only the Naches, Marsh, and Sesech populations would be considered suitable reference populations for the Chiwawa supplementation program. Both the Entiat and Little Wenatchee populations failed to meet the minimum score, largely because of the influence of hatchery fish within those populations (i.e., relatively low pNOS values).
Table 11. Results from scoring potential reference populations using the selection criteria (pNOS, correlation, trend, and effect size). Populations with scores less than 81 were considered unsuitable as reference populations. Populations with scores equal to or greater than 81 were considered suitable references. These results were based on natural-log transformed data.

<table>
<thead>
<tr>
<th>Potential reference populations</th>
<th>Abundance</th>
<th>NORs</th>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naches</td>
<td>85</td>
<td>88</td>
<td>91</td>
</tr>
<tr>
<td>Entiat</td>
<td>23</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>Marsh</td>
<td>79</td>
<td>91</td>
<td>87</td>
</tr>
<tr>
<td>Sesech</td>
<td>84</td>
<td>85</td>
<td>88</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>51</td>
<td>53</td>
<td>49</td>
</tr>
</tbody>
</table>

An important benefit from scoring the different selection criteria is that the total scores can be used to weight the outcome of differing statistical results. For example, analyses may show that when three suitable reference populations are compared to the supplemented population, two of the reference populations may indicate a significant treatment effect, while the third indicates no effect. Under this scenario it is not clear if the supplementation program has or has not affected the abundance or productivity of the supplemented population. If, however, the two reference populations that produced a significant result had higher total scores than the reference population that did not indicate a significant result, one can place more weight on the results from populations with higher total scores.

**Conclusions**

The purpose of this exercise was to develop a method for selecting suitable reference populations that could be used to assess the effects of supplementation programs on spawner abundance, NORs, and productivity. The selection process included a three-step process (Figure 8). Step 1 identified populations with similar life-history characteristics, few or no hatchery spawners, a long time series of accurate abundance and productivity estimates, and similar freshwater habitat impairments and out-of-basin effects. Populations that met these criteria were then examined for their graphical and statistical relationship with the supplemented population (Step 2). The statistical analysis under Step 2 were converted to a quantitative model (Step 3) that was used to generate a weighted score for pNOS, correlation, trends, and effect sizes for each potential reference population. Reference populations with total scores of 81 or greater were selected as suitable reference populations.
We used this approach to select suitable reference populations for analyzing the effects of the Chiwawa spring Chinook supplementation program on fish abundance and productivity. The method indicated that the Naches, Marsh, and Sesech populations would serve as suitable reference populations for the Chiwawa spring Chinook supplementation program. Both the Entiat and Little Wenatchee populations failed to meet the minimum score, largely because of the influence of hatchery fish within those populations (i.e., relatively low pNOS values). However, because the presence of hatchery spring Chinook within those populations should decrease, they may serve as unique reference populations in which the comparisons change from...
all populations receiving hatchery fish to only the Chiwawa population receiving hatchery fish. Therefore, we will continue to include both the Little Wenatchee and Entiat populations in future analyses.

An important assumption in the use of reference populations is that the supplemented and reference populations that tracked each other before supplementation would continue to track each other in the absence of supplementation. Given that the reference populations did not match the Chiwawa population on all criteria examined (Table 1) and some reference populations tracked the Chiwawa population more poorly than others (Figures 2-7; Tables 2-4), there may be some uncertainty as to whether differences observed between the Chiwawa and reference populations during the supplementation period are associated with the hatchery program, “nuisance” factors\(^{17}\), or a combination of both. In addition, we have no ability to regulate or control activities in reference areas. Any large-scale change (man-made or natural) in reference areas could affect our ability to assess the effectiveness of the supplementation program.

Because we have no ability to maintain reference areas for long periods of time and may not be able to control all activities even within the supplemented populations, we propose the use of a “causal-comparative” approach to strengthen the certainty of our inferences (Pearsons and Temple 2010). The causal-comparative approach relies on correlative data to try and make a case for causal inference.\(^{18}\) Correlation is used to rule out alternative hypotheses (note that we make our case as much if not more by disproving plausible alternatives as we do by showing that the data are consistent with a hypothesis). For example, large scale land-use activities or natural events can affect stream flows, fine sediment recruitment, and water temperatures. Changes in these factors can affect the freshwater survival and productivity of fish independently of supplementation programs. If changes in habitat, migratory, and ocean conditions do not affect reference and treatment populations similarly, inferences associated with supplementation programs may be confounded. By measuring and tracking these extraneous factors within reference and treatment areas, we can assess the effects of these state variables on population conditions independent of the supplementation programs. This allows us to more effectively assess the influence of supplementation programs on populations.

To that end, we recommend that the following state variables be measured and tracked within the Chiwawa Basin and each of the reference areas: mean annual precipitation, total and riparian forest cover, road density, impervious surface, and alluvium. These variables can be used to describe differences in water temperatures at different life stages (pre-spawning, egg incubation, and summer rearing) and substrate characteristics, including fine sediments and embeddedness (Jorgensen et al. 2009). They can be used to assess possible changes in spawner abundance, NORs, and productivity that are independent of supplementation.

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\(^{17}\) A “nuisance” factor is any factor that is outside the control of the experimenter and can affect the response variable (spawner abundance or productivity). In this case, nuisance factors may include differences in freshwater habitat trends and conditions, out-of-basin effects (e.g., migration and ocean survival), and hatchery strays that affect the Chiwawa and reference populations differently.

\(^{18}\) It is important to point out that correlation does not demonstrate cause-and-effect. It only suggests a relationship between variables. Thus, inferences based on correlation lack the certainty that is associated with a design-based approach.
Analyses with Reference Populations

Once suitable reference populations are selected, methods for analyzing the supplemented and reference populations need to be identified. What follows is a description of different analyses that can be used to assess the effects of supplementation programs on spawner abundance, NORs, and productivity using reference populations. Later in this report we describe methods for assessing supplementation effects when reference populations are not available.

We used some of the reference populations selected for the Chiwawa program to illustrate the different methods for evaluating the effects of the supplementation program on spawner abundance, NORs, and productivity. For abundance, we selected the Naches, Entiat, Little Wenatchee, and Sesech populations as suitable references for the Chiwawa population. For NORs, we selected the Naches, Entiat, Marsh, and Little Wenatchee populations as suitable references. For productivity, we selected the Naches, Sesech, Little Wenatchee, and Marsh Creek as suitable references for the Chiwawa. As noted earlier, we included the Little Wenatchee and Entiat populations, even though they did not meet all the criteria for suitable reference populations.

Analysis of Trends

As a first step, we used trend analyses to assess the effects of the Chiwawa supplementation program on spring Chinook spawner abundance, NORs, and productivity. Here, we compared the slopes of the trends between each treatment/reference pair before and during supplementation using t-tests. If the hatchery program is successfully supplementing the natural spring Chinook population, trends in spawner abundance and NORs should deviate significantly (i.e., the slope of the supplemented population should be greater than the slopes of the reference populations during the supplementation period). For productivity, the slope of the supplemented population, relative to the reference population, should increase or remain the same.

Trend analysis indicated that the relationship of slopes of spawner abundance between the Chiwawa and reference populations did not change significantly after the initiation of supplementation (Figure 9; Table 12). This was true for both transformed and untransformed abundance data. Before supplementation, spawner abundances trended down in both the Chiwawa and reference populations (Figure 9). During the period of supplementation, abundances in both the Chiwawa and reference populations trended upward. Interestingly, in nearly all treatment/reference comparisons, the Pearson correlation coefficient was greater in the supplementation period than in the pre-supplementation period (Table 12). This was most evident in the transformed abundance data (Figure 9).
Figure 9. Trends in spring Chinook spawner abundance in the Chiwawa and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed spawner abundance data; those on the right include natural-log transformed data.
Table 12. Pearson correlation coefficients and t-test results comparing slopes of spawner abundance trends between reference populations and the Chiwawa spring Chinook population before and during the supplementation periods; for correlation coefficients, an asterisk (*) indicates significance at P < 0.05. Analyses include both untransformed and natural-log transformed spawner abundance data.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Pearson correlation coefficient</th>
<th>Test on slopes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>During</td>
<td>Before</td>
</tr>
<tr>
<td>Spawner Abundance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.684*</td>
<td>0.595</td>
<td>-0.659</td>
</tr>
<tr>
<td>Entiat</td>
<td>0.598*</td>
<td>0.672*</td>
<td>-0.596</td>
</tr>
<tr>
<td>Sesech</td>
<td>0.274</td>
<td>0.904*</td>
<td>-1.265</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.399</td>
<td>0.685*</td>
<td>-0.591</td>
</tr>
</tbody>
</table>

| LN Spawner Abundance |        |        |        |        |        |        |
| Naches               | 0.642* | 0.813* | -1.323 | -0.047 | 0.222  | 0.963  |
| Entiat               | 0.652* | 0.860* | 0.412  | 0.422  | 0.685  | 0.678  |
| Sesech               | 0.149  | 0.878* | -1.431 | -0.333 | 0.170  | 0.743  |
| Little Wenatchee     | 0.670* | 0.861* | 1.325  | 0.316  | 0.202  | 0.756  |

Trend analysis indicated that the relationship of slopes of NORs between the Chiwawa and reference populations did not change significantly after the initiation of supplementation (Figure 10; Table 13). Before supplementation, Chiwawa NORs trended downward more strongly than the reference populations (Figure 10). However, during the supplementation period, both the Chiwawa and reference population NORs trended upward in parallel. In nearly all treatment/reference comparisons, the Pearson correlation coefficient was greater in the pre-supplementation period than in the supplementation period (Table 13).
Figure 10. Trends in spring Chinook natural-origin recruits (NORs) in the Chiwawa and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed NORs; those on the right include natural-log transformed data.
Table 13. Pearson correlation coefficients and t-test results comparing slopes of natural-origin recruits trends between reference populations and the Chiwawa spring Chinook population before and during the supplementation periods; for correlation coefficients, an asterisk (*) indicates significance at \( P < 0.05 \). Analyses include both untransformed and natural-log transformed natural-origin recruits.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Pearson correlation coefficient</th>
<th>Test on slopes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>During</td>
</tr>
<tr>
<td><strong>Natural-Origin Recruits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.803*</td>
<td>0.432</td>
</tr>
<tr>
<td>Entiat</td>
<td>0.795*</td>
<td>0.754*</td>
</tr>
<tr>
<td>Marsh</td>
<td>0.605*</td>
<td>0.677*</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.880*</td>
<td>0.758*</td>
</tr>
<tr>
<td><strong>LN Natural-Origin Recruits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.824*</td>
<td>0.710*</td>
</tr>
<tr>
<td>Entiat</td>
<td>0.886*</td>
<td>0.796*</td>
</tr>
<tr>
<td>Marsh</td>
<td>0.830*</td>
<td>0.835*</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.927*</td>
<td>0.898*</td>
</tr>
</tbody>
</table>

As with NORs and spawner abundance data, trend analysis indicated that the relationship of slopes of productivity (recruits/spawner) between the Chiwawa and reference populations did not change significantly after the initiation of supplementation (Figure 11; Table 14). This was true for both transformed and untransformed productivity data. Before supplementation, productivities trended down in both the Chiwawa and reference populations (Figure 11). During the period of supplementation, productivities fluctuated widely in both the Chiwawa and reference populations. Nevertheless, during the supplementation period, productivities generally increased in both the reference and Chiwawa populations. Unlike with spawner abundance, the Pearson correlation coefficients resulting from analysis of productivity data were generally higher in the pre-supplementation period than during the supplementation period (Table 14).
**Figure 11.** Trends in spring Chinook productivity (recruits/spawner) in the Chiwawa (supplemented) and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed productivity data; those on the right include natural-log transformed data.
Table 14. Pearson correlation coefficients and t-test results comparing slopes of productivity (recruits/spawner) trends between reference populations and the Chiwawa spring Chinook population before and during the supplementation periods; for correlation coefficients, an asterisk (*) indicates significance at P < 0.05. Analyses include both untransformed and natural-log transformed productivity data.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Pearson correlation coefficient</th>
<th>Test on slopes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>During</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.960*</td>
<td>0.802*</td>
</tr>
<tr>
<td>Marsh</td>
<td>0.320</td>
<td>0.910*</td>
</tr>
<tr>
<td>Sesech</td>
<td>0.903*</td>
<td>0.491</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.848*</td>
<td>0.864*</td>
</tr>
<tr>
<td><strong>LN Productivity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.944*</td>
<td>0.805*</td>
</tr>
<tr>
<td>Marsh</td>
<td>0.610*</td>
<td>0.804*</td>
</tr>
<tr>
<td>Sesech</td>
<td>0.913*</td>
<td>0.531</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.862*</td>
<td>0.751*</td>
</tr>
</tbody>
</table>

Using trend analysis, we found no evidence that the supplementation program has significantly increased the spawner abundance and NORs of spring Chinook in the Chiwawa Basin. Even though we documented an increasing trend in spawner abundance and NORs during the supplementation period, a similar increase in spawner abundance and NORs was observed in the reference populations. In addition, we found no evidence that the supplementation program has increased the productivity of spring Chinook in the Chiwawa Basin. Importantly, the productivity of spring Chinook in the Chiwawa Basin did not trend downward during the supplementation period. Thus, based on trend analysis, it appears that the supplementation program has not increased or decreased the abundance and productivity of spring Chinook in the Chiwawa Basin.

We note that this exercise only tests the slopes of the trend lines. It does not test for differences in elevations of the trend lines. A supplementation program could increase spawner abundance, NORs, and productivity of the target population without changing the slopes of the trend lines. That is, supplementation could cause the elevation of the trend line to be greater during the supplementation period than during the pre-supplementation period. In the next section we evaluate elevation differences by testing mean differences before and after supplementation.

**Analysis of Mean Differences, Ratios, and Rates**

For assessing mean differences between supplemented and reference populations, we derived three different response variables using transformed and untransformed spawner abundance, NORs, and productivity data. The first included difference scores, which were calculated as the difference between paired treatment and reference data (T-R). The second included ratios, which were calculated as the ratio of paired treatment and reference data (T/R). Finally, we calculated
the differences in annual changes in paired treatment and reference population data (ΔT-ΔR; see footnote #2).

If the hatchery program is successfully supplementing the natural spring Chinook population, the mean difference or ratio score of paired spawner abundance data and NORs during the supplementation period should be greater than the pre-supplementation period. For productivity, the mean difference or ratio score during the supplementation period should be equal to or higher than the pre-supplementation period. We tested the following statistical hypotheses.

Spawner Abundance and NORs:

- **Ho:** Mean Difference (or Ratio) before supplementation ≥ Mean Difference (or Ratio) during supplementation.
- **Ha:** Mean Difference (or Ratio) before supplementation < Mean Difference (or Ratio) during supplementation (i.e., \(\mu_{\text{pre}} - \mu_{\text{post}} < 0\)).

Productivity (Recruits/Spawner):

- **Ho:** Mean Difference (or Ratio) before supplementation ≤ Mean Difference (or Ratio) during supplementation.
- **Ha:** Mean Difference (or Ratio) before supplementation > Mean Difference (or Ratio) during supplementation (i.e., \(\mu_{\text{pre}} - \mu_{\text{post}} > 0\)).

For each set of response variables, we tested before/after supplementation effects using a one-tailed Aspin-Welch unequal-variance test. We used the Aspin-Welch unequal-variance test instead of Student’s t-test, because in nearly every case, the variances of response variables in the pre-treatment and supplementation periods were unequal. This was true even for natural-log transformed variables. We used the modified Levene equal-variance test to assess the equality of variance. In some cases, the distributions of response variables were not normal (based on the Omnibus Normality test and examination of histograms, normal probability plots, and box plots). Therefore, we also used a randomization test, based on 10,000 Monte Carlo simulations, to assess differences in response variables before and during supplementation. The randomization procedure only allowed the testing of two-tailed hypotheses. Therefore, we generated 95% confidence intervals on the mean difference (\(\mu_{\text{pre}} - \mu_{\text{post}}\)) using bootstrapping methods to determine the direction of the difference. We generated 5,000 bootstrap samples to calculate confidence intervals.

All these statistical methods assume that the samples of derived difference or ratio scores from the pre-supplementation and supplementation periods were independent. However, BACI designs, like time-series trend analysis, are repeated-measures designs and therefore are susceptible to temporal correlations in the data. This means that the two samples of difference or ratio scores may not be independent. Under this scenario, ARIMA models can be used to describe the correlation structure in temporal data (Gotelli and Ellison 2004). ARIMA models can be fit individually to the reference and supplemented time series data, or to a derived data

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19 Because of the logic of null hypothesis testing, the rejection of the null hypothesis of no difference in productivity would mean that the supplementation program has reduced the productivity of the target population (here rejection of the null indicates “harm”). Notice that the rejection of the null hypothesis of no difference in spawner abundance means that the supplementation program has improved the spawner abundance in the target population (here rejection of the null indicates “benefit”).

20 In cases in which the variances were equal, both the Aspin-Welch test and Student’s t-test gave the same result.
series created by taking the ratio or difference of the supplemented/reference data at each time step. ARIMA models, however, require a long time series (N > 40) and therefore we could not use them to model the spring Chinook data. Thus, we acknowledge that our analyses may be confounded if the samples are not independent.

*Difference Scores (T-R)*

Analysis of supplementation effects on spawner abundance using difference scores indicated that supplementation did not significantly increase spawning abundance in the Chiwawa Basin (Table 15; Figure 12). Only the Little Wenatchee-Chiwawa pairing using transformed abundance data indicated a significant increase in spawning abundance following supplementation. The randomization test indicated significant differences in several of the treatment-reference pairs; however, the bootstrap CIs indicated that those differences were in the wrong direction (i.e., CIs > 0). That is, compared to the reference populations, spawner abundance decreased in the Chiwawa Basin during the supplementation period (Figure 12).

**Table 15.** Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spawner abundance data. Tests determined if the mean difference scores during the supplementation period were greater than mean difference scores during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td><strong>Spawner Abundance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>1.066</td>
<td>0.848</td>
<td>184</td>
</tr>
<tr>
<td>Entiat</td>
<td>1.872</td>
<td>0.962</td>
<td>316</td>
</tr>
<tr>
<td>Sesech</td>
<td>4.502</td>
<td>0.999</td>
<td>607</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>1.773</td>
<td>0.954</td>
<td>321</td>
</tr>
<tr>
<td><strong>LN Spawner Abundance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>2.603</td>
<td>0.990</td>
<td>0.701</td>
</tr>
<tr>
<td>Entiat</td>
<td>1.701</td>
<td>0.946</td>
<td>0.388</td>
</tr>
<tr>
<td>Sesech</td>
<td>5.394</td>
<td>0.999</td>
<td>1.327</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-2.259</td>
<td>0.018</td>
<td>0.609</td>
</tr>
</tbody>
</table>
Figure 12. Mean difference (Treatment – Reference) scores of untransformed (figures on the left) and transformed (figures on the right) spawner abundance, natural-origin recruits (NORs), and productivity data before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Positive effects of supplementation on spawner abundance and NORs are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Analysis of supplementation effects on NORs using difference scores indicated that supplementation did not significantly increase NORs in the Chiwawa Basin (Table 16; Figure 12). The randomization test indicated significant differences in several of the treatment-reference pairs; however, the bootstrap CIs indicated that those differences were in the wrong direction. That is, compared to the reference populations, NORs decreased in the Chiwawa Basin during the supplementation period (Figure 12).
Table 16. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed natural-origin recruits. Tests determined if the mean difference scores during the supplementation period were greater than mean difference scores during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td>Natural-Origin Recruits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>1.787</td>
<td>0.953</td>
<td>537</td>
</tr>
<tr>
<td>Entiat</td>
<td>2.879</td>
<td>0.993</td>
<td>558</td>
</tr>
<tr>
<td>Marsh</td>
<td>3.817</td>
<td>0.999</td>
<td>795</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>2.668</td>
<td>0.991</td>
<td>510</td>
</tr>
<tr>
<td>LN Natural-Origin Recruits</td>
<td>0.430</td>
<td>0.659</td>
<td>0.354</td>
</tr>
<tr>
<td>Entiat</td>
<td>0.788</td>
<td>0.779</td>
<td>0.445</td>
</tr>
<tr>
<td>Marsh</td>
<td>1.45</td>
<td>0.916</td>
<td>0.953</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-0.813</td>
<td>0.214</td>
<td>-0.319</td>
</tr>
</tbody>
</table>

Analysis of supplementation effects on productivity (adult recruits/spawner) using difference scores indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 17; Figure 12). All tests, regardless of treatment-reference pairs, indicated that productivity did not change significantly during the supplementation period. These tests indicate that supplementation has not negatively affected the productivity of spring Chinook salmon in the Chiwawa Basin.

Table 17. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data. Tests determined if the mean difference scores during the supplementation period were less than mean difference scores during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>1.134</td>
<td>0.139</td>
<td>0.594</td>
</tr>
<tr>
<td>Marsh</td>
<td>-0.203</td>
<td>0.579</td>
<td>0.152</td>
</tr>
<tr>
<td>Sesech</td>
<td>1.607</td>
<td>0.071</td>
<td>1.435</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.431</td>
<td>0.335</td>
<td>0.147</td>
</tr>
<tr>
<td>LN Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.770</td>
<td>0.227</td>
<td>0.104</td>
</tr>
<tr>
<td>Marsh</td>
<td>0.012</td>
<td>0.495</td>
<td>0.003</td>
</tr>
<tr>
<td>Sesech</td>
<td>1.463</td>
<td>0.087</td>
<td>0.343</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.390</td>
<td>0.351</td>
<td>0.060</td>
</tr>
</tbody>
</table>
Ratio Scores (T/R)

As with difference scores, analysis of supplementation effects on spawner abundance using ratios indicated that supplementation did not significantly increase spawning abundance in the Chiwawa Basin (Table 18; Figure 13). Only the Little Wenatchee-Chiwawa pairing indicated a significant increase in spawning abundance following supplementation. Analysis with both transformed and untransformed Little Wenatchee-Chiwawa data indicated a significant effect. In contrast, only difference scores derived from transformed data indicated a significant effect. The randomization test indicated significant differences in several of the treatment-reference pairs; however, the bootstrap CIs indicated that those differences were in the wrong direction. That is, compared to the reference populations, spawner abundance decreased in the Chiwawa Basin during the supplementation period (Figure 13).

Table 18. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spawner abundance data. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td>Spawner Abundance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>2.110</td>
<td>0.970</td>
<td>0.398</td>
</tr>
<tr>
<td>Entiat</td>
<td>1.254</td>
<td>0.888</td>
<td>0.731</td>
</tr>
<tr>
<td>Sesech</td>
<td>4.251</td>
<td>0.999</td>
<td>2.428</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-2.649</td>
<td>0.009</td>
<td>3.897</td>
</tr>
<tr>
<td>LN Spawner Abundance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>2.783</td>
<td>0.993</td>
<td>0.120</td>
</tr>
<tr>
<td>Entiat</td>
<td>1.273</td>
<td>0.890</td>
<td>0.055</td>
</tr>
<tr>
<td>Sesech</td>
<td>5.143</td>
<td>0.999</td>
<td>0.244</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-3.462</td>
<td>0.002</td>
<td>0.327</td>
</tr>
</tbody>
</table>
Figure 13. Mean ratios (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) spawner abundance, natural-origin recruits (NORs), and productivity data before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Positive effects of supplementation on spawner abundance and NORs are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Analysis of supplementation effects on NORs using ratios indicated that supplementation did not significantly increase NORs in the Chiwawa Basin (Table 19; Figure 13). Only the Little Wenatchee-Chiwawa pairing indicated a significant increase in transformed NORs following supplementation. The randomization test indicated significant differences in several of the treatment-reference pairs; however, the bootstrap CIs indicated that those differences were in the wrong direction. That is, compared to the reference populations, NORs decreased in the Chiwawa Basin during the supplementation period (Figure 13).
Table 19. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed natural-origin recruits. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td>Natural-Origin Recruits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>1.318</td>
<td>0.881</td>
<td>0.306</td>
</tr>
<tr>
<td>Entiat</td>
<td>2.447</td>
<td>0.987</td>
<td>2.172</td>
</tr>
<tr>
<td>Marsh</td>
<td>2.001</td>
<td>0.965</td>
<td>3.638</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-1.148</td>
<td>0.136</td>
<td>2.020</td>
</tr>
<tr>
<td>LN Natural-Origin Recruits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.057</td>
<td>0.522</td>
<td>0.009</td>
</tr>
<tr>
<td>Entiat</td>
<td>0.359</td>
<td>0.638</td>
<td>0.049</td>
</tr>
<tr>
<td>Marsh</td>
<td>0.603</td>
<td>0.721</td>
<td>0.161</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-1.914</td>
<td>0.038</td>
<td>0.277</td>
</tr>
</tbody>
</table>

Analysis of supplementation effects on productivity (adult recruits/spawner) using ratios indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 20; Figure 13). Although the Aspin-Welch test indicated a significant effect when comparing the Chiwawa to the Marsh Creek population, both the randomization test and the bootstrap CI did not indicate a significant effect. These tests indicate that supplementation has probably not negatively affected the productivity of spring Chinook salmon in the Chiwawa Basin.

Table 20. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>-0.677</td>
<td>0.745</td>
<td>0.209</td>
</tr>
<tr>
<td>Marsh</td>
<td>2.236</td>
<td>0.022</td>
<td>0.814</td>
</tr>
<tr>
<td>Sesech</td>
<td>0.677</td>
<td>0.253</td>
<td>0.191</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.033</td>
<td>0.487</td>
<td>0.018</td>
</tr>
<tr>
<td>LN Productivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>-0.639</td>
<td>0.734</td>
<td>0.148</td>
</tr>
<tr>
<td>Marsh</td>
<td>1.952</td>
<td>0.036</td>
<td>0.613</td>
</tr>
<tr>
<td>Sesech</td>
<td>0.447</td>
<td>0.330</td>
<td>0.098</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-0.034</td>
<td>0.513</td>
<td>0.015</td>
</tr>
</tbody>
</table>
**Difference of Annual Difference Scores (ΔT-ΔR)**

Analysis of supplementation effects on spawner abundance using difference scores of annual changes indicated that supplementation did not significantly increase spawning abundance in the Chiwawa Basin (Table 21; Figure 14). None of the statistical analyses detected a significant increase in annual change in the Chiwawa Basin relative to the reference populations.

**Table 21.** Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spawner abundance data. Tests determined if mean difference scores of annual change during the supplementation period were greater than mean difference scores of annual change during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td><strong>Spawner Abundance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.009</td>
<td>0.503</td>
<td>2</td>
</tr>
<tr>
<td>Entiat</td>
<td>-0.239</td>
<td>0.407</td>
<td>48</td>
</tr>
<tr>
<td>Sesech</td>
<td>-0.126</td>
<td>0.451</td>
<td>20</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-0.318</td>
<td>0.377</td>
<td>65</td>
</tr>
<tr>
<td><strong>LN Spawner Abundance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>-0.425</td>
<td>0.339</td>
<td>0.142</td>
</tr>
<tr>
<td>Entiat</td>
<td>-0.084</td>
<td>0.467</td>
<td>0.028</td>
</tr>
<tr>
<td>Sesech</td>
<td>-0.349</td>
<td>0.366</td>
<td>0.117</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.001</td>
<td>0.500</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Figure 14. Mean difference scores of annual changes (ΔTreatment – ΔReference) of untransformed (figures on the left) and transformed (figures on the right) spawner abundance and productivity data before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin.

Analysis of supplementation effects on NORs using difference scores of annual changes indicated that supplementation did not significantly increase NORs in the Chiwawa Basin (Table 22; Figure 14). None of the statistical analyses detected a significant increase in annual change in the Chiwawa Basin relative to the reference populations.
Table 22. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed natural-origin recruits. Tests determined if mean difference scores of annual change during the supplementation period were greater than mean difference scores of annual change during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value  P-value    Effect size</td>
<td>t-value  P-value</td>
<td></td>
</tr>
<tr>
<td><strong>Natural-Origin Recruits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.399  0.652  184</td>
<td>0.741</td>
<td>-699 – 989</td>
</tr>
<tr>
<td>Entiat</td>
<td>-1.381 0.092 202</td>
<td>0.194</td>
<td>-471 – 86</td>
</tr>
<tr>
<td>Marsh</td>
<td>-0.505 0.311 88</td>
<td>0.624</td>
<td>-425 – 206</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-1.437 0.084 214</td>
<td>0.179</td>
<td>-481 – 64</td>
</tr>
<tr>
<td><strong>LN Natural-Origin Recruits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>-1.301 0.118 1.214</td>
<td>0.224</td>
<td>-2.783 – 0.531</td>
</tr>
<tr>
<td>Entiat</td>
<td>-1.408 0.088 0.901</td>
<td>0.188</td>
<td>-1.977 – 0.387</td>
</tr>
<tr>
<td>Marsh</td>
<td>-0.712 0.244 0.570</td>
<td>0.517</td>
<td>-1.952 – 0.975</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-1.154 0.132 0.674</td>
<td>0.274</td>
<td>-1.706 – 0.497</td>
</tr>
</tbody>
</table>

Analysis of supplementation effects on productivity (adult recruits/spawner) using difference scores of annual changes indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 23; Figure 14). All tests, regardless of treatment-reference pairs, indicated that productivity did not change significantly during the supplementation period.

Table 23. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data. Tests determined if the mean difference scores of annual change during the supplementation period were less than mean difference scores of annual change during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value  P-value    Effect size</td>
<td>t-value  P-value</td>
<td></td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.002  0.475  0.054</td>
<td>0.952</td>
<td>-1.464 – 1.583</td>
</tr>
<tr>
<td>Marsh</td>
<td>-0.063 0.525 0.074</td>
<td>0.948</td>
<td>-2.395 – 2.031</td>
</tr>
<tr>
<td>Sesech</td>
<td>-0.317 0.621 0.350</td>
<td>0.628</td>
<td>-2.387 – 1.695</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-0.347 0.633 0.163</td>
<td>0.728</td>
<td>-1.023 – 0.725</td>
</tr>
<tr>
<td><strong>LN Productivity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.000  0.500 0.000</td>
<td>0.999</td>
<td>-0.408 – 0.445</td>
</tr>
<tr>
<td>Marsh</td>
<td>-0.126 0.549 0.044</td>
<td>0.904</td>
<td>-0.715 – 0.595</td>
</tr>
<tr>
<td>Sesech</td>
<td>-0.449 0.668 0.144</td>
<td>0.727</td>
<td>-0.685 – 0.509</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-0.200 0.578 0.047</td>
<td>0.842</td>
<td>-0.466 – 0.391</td>
</tr>
</tbody>
</table>
We believe results from analysis of mean differences of annual change (ΔT-ΔR) in spawning abundance, NORs, and productivity are difficult to interpret and may be insensitive to treatment effects. A simpler analysis, which is also easier to interpret, is the use of trend analysis. Therefore, we recommend that analyses using differences of annual change be replaced with trend analysis.

**Corrections for Density Dependence and Carrying Capacity**

The analyses described above assume that the density of spawners or recruits does not affect the survival and productivity of fish. However, it is well known that the density of fish can affect the number of recruits as well as the productivity of the population. This occurs through the relationship between density and mortality. Mortality of fish can be generally classified as density independent and density dependent. In general, when densities are low, the mortality is density independent, but as densities increase, the amount of density-dependent mortality increases. Monitoring programs can make use of this information to derive density-corrected estimates of productivity. In this section, we describe two different methods for deriving density-corrected estimates of productivity.

The first method controlled the effects of density on productivity (adult recruits/spawner; R/S) by partitioning observed productivities into density-independent and density-dependent productivity. When abundance is below the minimum number of spawners (S) needed to produce the maximum number of recruits (K_sp), the observed productivity is used in statistical tests. However, when the abundance is equal to or above K_sp, the modeled value of productivity (R/K_sp) is used in statistical tests.

$$\text{Adj } R/S = \begin{cases} R/S, & \text{if } S < K_{sp} \\ R/K_{sp}, & \text{if } S \geq K_{sp} \end{cases}$$

The density-independent and density-dependent productivities were then combined in a single test.

The second method was based on one of the goals of supplementation, which is to fill the capacity of the environment with fish. This method corrects for differences in carrying capacities between the supplemented and reference populations. We did this by calculating the percent saturation of NORs. That is, we calculated the fraction of the habitat (τ) that was filled with NORs by dividing the observed NOR by the modeled maximum number of NORs (K_R) that the habitat could support.

$$\tau = \frac{NOR_{obs}}{K_R}$$

Note that 1-τ represents the unused portion of the carrying capacity and is the term that is multiplied by the exponential growth equation to derive the logistic growth equation. We included τ in the statistical analyses.
These two methods require the estimation of carrying capacity ($K_R$) and the spawning abundance that produces the maximum number of recruits ($K_{sp}$). We estimated these parameters for both reference populations and the supplemented population using Ricker, Beverton-Holt, and smooth hockey stick stock-recruitment models. We used only spawner abundance as a predictor of subsequent brood recruitment. We made the following assumptions in proceeding with the analysis:

- **Density-dependent mortality**—For some time period before recruitment, the brood instantaneous mortality rate is proportional to the number of parent spawners (Ricker 1954).
- **Lognormal variation**—At any particular spawning stock size, the variation in recruitment is log-normally distributed about its average, and acts multiplicatively (Quinn and Deriso 1999).
- **Measurement error**—Error in spawning stock size estimates (measurement error) is small relative to the range of spawning stock sizes observed (Hilborn and Walters 1992). Variation in realized recruitment at any particular spawning stock size (process error) dominates recruitment measurement error.
- **Stationarity**—The average stock-recruitment relationship is constant over time (Hilborn and Walters 1992). That is, environmental conditions randomly affect survival independent of stock size or time.

In general, the methods we used to fit the models to the data followed those outlined in Hilborn and Walters (1992) and Froese (2008). The Ricker model, which assumes that the number of recruits increases to a maximum and then declines as the number of spawners increases, takes the form:

$$E(R) = \alpha S e^{-\beta S}$$

where $E(R)$ is the expected recruitment, $S$ is spawner abundance, $\alpha$ is the number of recruits per spawner at low spawning levels, and $\beta$ describes how quickly the recruits per spawner drop as the number of spawners increases. We estimated $K_R$ as:

$$K_R = \left(\frac{\alpha}{\beta}\right) e^{-1}$$

and $K_{sp}$ as:

$$K_{sp} = \frac{1}{\beta}$$

The Beverton-Holt model assumes that the number of recruits increases constantly toward an asymptote as the number of spawners increases. After the asymptote is reached, the number of recruits neither increases nor decreases. The asymptote represents the maximum number of recruits the system can support (i.e., carrying capacity for the system; $K_R$). The Beverton-Holt curve takes the form:

$$E(R) = \frac{(\alpha S)}{(\beta + S)}$$

where $E(R)$ and $S$ are as above, $\alpha$ is the maximum number of recruits produced ($K_R$), and $\beta$ is the number of spawners needed to produce (on average) recruits equal to one-half the maximum
number of recruits. Because $K_{sp} = \infty$ in the Beverton-Holt model, we estimated $K_{sp}$ as the number of spawners needed to produce $0.99(K_{R})$.

Like the Beverton-Holt model, the smooth hockey stick model assumes that the number of recruits increases toward an asymptote (carrying capacity; $K_{R}$) as the number of spawners increases. After the carrying capacity is reached, the number of recruits neither increases nor decreases. The carrying capacity represents the maximum number of recruits the system can support. This curve takes the form (Froese 2008):

$$E(R) = R\infty \left(1 - e^{-\left(\frac{\alpha}{R\infty}\right)S}\right)$$

where $E(R)$ and $S$ are as above, $\alpha$ is the slope at the origin of the spawner-recruitment curve, and $R\infty$ is the carrying capacity of recruits (note that $R\infty = K_{R}$). As with the Beverton-Holt model, we estimated $K_{sp}$ as the number of spawners needed to produce $0.99(K_{R})$.

We used non-linear regression to fit the three models to spawner-recruitment data. Before fitting the models, we transformed recruitment data using natural logs. We estimated bias and uncertainty measures (95% CI) for the model parameters using bootstrap procedures, which assumed that the $\{R, S\}$ sample represented or approximated the population. The number of bootstrap samples was 3,000. We computed and stored the non-linear regression results for each bootstrap sample. We then calculated the bootstrap 95% CI by arranging the 3,000 bootstrap parameter values in sorted order and selected the 2.5 and 97.5 percentiles from the list.

We used Akaike’s Information Criterion for small sample size ($AICc$) to determine which model(s) best explained the relationship between spawners and recruitment in the supplemented and reference populations. $AICc$ was estimated as:

$$AICc = -2\log(\mathcal{L}(\theta|data)) + 2K + \frac{2K(K + 1)}{n - K - 1}$$

where $\log(\mathcal{L}(\theta|data))$ is the maximum likelihood estimate, $K$ is the number of estimable parameters (structural parameters plus the residual variance parameter), and $n$ is the sample size (Burnham and Anderson 2002). We used least-squares methods to estimate $\log(\mathcal{L}(\theta|data))$, which was calculated as $\log(\sigma^2)$, where $\sigma^2 = \text{residual sum of squares divided by the sample size}$ ($\sigma^2 = \text{RSS}/n$). $AICc$ assessed model fit in relation to model complexity (number of parameters). The model with the smallest $AICc$ value represented the “best approximating” model within the model set. Remaining models were ranked relative to the best model using $AICc$ difference scores ($\Delta AICc$), Akaike weights ($w_i$), and evidence ratios. Models with $\Delta AICc$ values less than 2 indicated that there is substantial support for these models as being the best-fitting models within the set (Burnham and Anderson 2002). Models with values greater than 2 had less support. Akaike weights are probabilities estimating the strength of the evidence supporting a particular model as being the best model within the model set. Models with small $w_i$ values are less plausible as competing models (Burnham and Anderson 2002). If no single model could be specified as the best model, a “best subset” of competing models was identified using (1) $AICc$ differences to indicate the level of empirical support each model had as being the best model, (2) evidence ratios based on Akaike weights to indicate the relative probability that any model is the best model, and (3) coefficients of determination ($R^2$) assessing the explanatory power of each model.
Stock-Recruitment Analysis

We successfully fit stock-recruitment models to the Chiwawa and reference population data. The span of spawner data for the Chiwawa and reference populations was greater than 14 times the minimum observed spawners, which should provide sufficient contrast for estimation of model parameters. In addition, the span of recruitment data was greater than 12 times the minimum observed recruitment, again providing sufficient contrast for estimation of parameters. The relationship between natural log R/S and spawners indicated that some of the highest productivities occurred at the lower spawner levels and the lowest productivities generally occurred at the highest spawner levels (Figure 15). This is consistent with the assumption of density-dependent mortality.

Although model fits were generally poor, explaining less than 40% of the residual variation in natural-log recruitment data, we were able to estimate average maximum recruitment levels ($K_R$) and the spawning levels needed to produce maximum recruitment ($K_{sp}$) (Table 24; Figure 15). For all populations examined, Akaike information criterion was unable to identify a best approximating model (i.e., $\Delta AIC_c$ values were less than 2, indicating support for all three models). However, evaluation of 95% CIs and the asymptotic correlation coefficients indicated that the smooth hockey stick model may be the best approximating model for each population. Therefore, we used estimates of $K_R$ and $K_{sp}$ derived from the smooth hockey stick model to correct for density dependence and different carrying capacities in treatment-reference comparisons.

As part of the regression diagnostics, we examined the dependence of the model residuals on time and found a significant ($P < 0.05$), positive, one-year-lag autocorrelation for the Entiat (0.562), Marsh (0.551), Sesech (0.564), and Little Wenatchee (0.629) populations. For the purposes of our work here, we did not attempt to correct for this one-year-lag correlation in the residuals. Future analyses will explore the use of autoregressive models (e.g., AR1; Noakes et al. 1987) to correct for autocorrelation.
Figure 15. Relationships between natural log recruits/spawner (LN R/S) and spawners (Stock) in the Chiwawa and reference populations (figures on the left) and relationships between numbers of untransformed recruits and spawners in the Chiwawa and reference populations (figures on the right). Figures on the right also show the fit of the Ricker, Beverton-Holt, and the smooth hockey stick models to the data (black straight line represents R=S).
Table 24. Results from fitting Ricker, Beverton-Holt, and smooth hockey stick models to stock-recruitment data from the Chiwawa and reference populations. 95% CI on parameter estimates are based on 3,000 bootstrap trials; Corr coef = asymptotic correlation of the parameter estimates; KR = maximum natural origin recruits (recruits at carrying capacity); Ksp = number of spawners needed to produce KR; AICc = Akaike’s Information Criterion for small sample size; Adj R^2 = coefficient of determination that is adjusted for the number of parameters in the model.

<table>
<thead>
<tr>
<th>Model</th>
<th>Parameter</th>
<th>Parameter value</th>
<th>Bootstrap 95% CI</th>
<th>Corr coef</th>
<th>KR</th>
<th>Ksp</th>
<th>AICc</th>
<th>Adj R^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiwawa Population</td>
<td>Ricker</td>
<td>α 0.7048</td>
<td>-0.6197 1.1055</td>
<td>0.791</td>
<td>852</td>
<td>3,285</td>
<td>-47.949</td>
<td>0.125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β 0.000304</td>
<td>-0.000668 0.000609</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beverton-Holt</td>
<td>α 1687.4</td>
<td>-65654539 3062.1</td>
<td>0.989</td>
<td>1,687</td>
<td>43,760</td>
<td>-47.962</td>
<td>0.125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β 2308.5</td>
<td>-99999538 4526.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smooth hockey stick</td>
<td>α 6.956</td>
<td>-41.313 8.2270</td>
<td>-0.708</td>
<td>1,049</td>
<td>6,847</td>
<td>-47.949</td>
<td>0.125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β 0.7118</td>
<td>-2.397 1.122</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches Population</td>
<td>Ricker</td>
<td>α 2.5223</td>
<td>-2.0003 3.9672</td>
<td>0.844</td>
<td>912</td>
<td>983</td>
<td>-45.063</td>
<td>-0.143</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β 0.001018</td>
<td>-0.000752 0.001717</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Beverton-Holt</td>
<td>α 869.4</td>
<td>97.4 1641.4</td>
<td>0.858</td>
<td>869</td>
<td>11,455</td>
<td>-46.801</td>
<td>-0.097</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β 111.8</td>
<td>-346.2 569.8</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smooth hockey stick</td>
<td>α 6.612</td>
<td>-89.071 12.026</td>
<td>-0.399</td>
<td>744</td>
<td>565</td>
<td>-46.831</td>
<td>-0.095</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β 6.013</td>
<td>-2.397 1.122</td>
<td></td>
<td></td>
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<tr>
<td>Entiat Population</td>
<td>Ricker</td>
<td>α 1.5843</td>
<td>0.1609 2.4178</td>
<td>0.867</td>
<td>167</td>
<td>286</td>
<td>-68.365</td>
<td>-0.049</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β 0.003496</td>
<td>0.001141 0.005906</td>
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<tr>
<td></td>
<td>Beverton-Holt</td>
<td>α 186.1</td>
<td>67.9 304.3</td>
<td>0.880</td>
<td>186</td>
<td>1,277</td>
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<tr>
<td></td>
<td></td>
<td>β 65.0</td>
<td>-59.1 189.2</td>
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<td>Smooth hockey stick</td>
<td>α 5.045</td>
<td>4.381 5.378</td>
<td>-0.450</td>
<td>155</td>
<td>344</td>
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<tr>
<td></td>
<td></td>
<td>β 2.180</td>
<td>-89.369 3.704</td>
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<tr>
<td>Marsh Creek Population</td>
<td>Ricker</td>
<td>α 1.1852</td>
<td>-1.8268 1.9269</td>
<td>0.823</td>
<td>241</td>
<td>552</td>
<td>-32.237</td>
<td>0.218</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β 0.001810</td>
<td>-0.003063</td>
<td></td>
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<tr>
<td>Model</td>
<td>Parameter</td>
<td>Parameter value</td>
<td>Bootstrap 95% CI</td>
<td>Corr coef</td>
<td>KR</td>
<td>Kp</td>
<td>AICc</td>
<td>Adj R²</td>
</tr>
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<td>-----------</td>
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<tr>
<td>Beverton-Holt</td>
<td>α</td>
<td>383.3</td>
<td>-85109314 - 665.4</td>
<td>0.970</td>
<td>383</td>
<td>5,310</td>
<td>-32.291</td>
<td>0.234</td>
</tr>
<tr>
<td></td>
<td>β</td>
<td>282.4</td>
<td>-99999944 - 564.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth hockey stick</td>
<td>α</td>
<td>5.565</td>
<td>-22.631 - 6.584</td>
<td>-0.694</td>
<td>261</td>
<td>984</td>
<td>-32.264</td>
<td>0.227</td>
</tr>
<tr>
<td></td>
<td>β</td>
<td>1.265</td>
<td>-108.574 - 2.531</td>
<td></td>
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</tr>
<tr>
<td><strong>Sesech Population</strong></td>
<td>Ricker</td>
<td>α</td>
<td>1.6835</td>
<td>-2.9253 - 2.5951</td>
<td>0.912</td>
<td>421</td>
<td>680</td>
<td>-54.589</td>
</tr>
<tr>
<td></td>
<td>β</td>
<td>0.001470</td>
<td>-0.002951 - 0.002941</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beverton-Holt</td>
<td>α</td>
<td>689.9</td>
<td>-986.8 - 2366.7</td>
<td>0.981</td>
<td>690</td>
<td>6,591</td>
<td>-54.678</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>β</td>
<td>351.7</td>
<td>-1059.0 - 1762.5</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Smooth hockey stick</td>
<td>α</td>
<td>6.1528</td>
<td>-22.851 - 6.815</td>
<td>-0.821</td>
<td>470</td>
<td>1,185</td>
<td>-54.633</td>
<td>-0.002</td>
</tr>
<tr>
<td></td>
<td>β</td>
<td>0.8000</td>
<td>-119.370 - 2.909</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Little Wenatchee Population</strong></td>
<td><strong>Ricker</strong></td>
<td>α</td>
<td>0.7447</td>
<td>0.0828 - 1.0280</td>
<td>0.735</td>
<td>356</td>
<td>1,298</td>
<td>-66.978</td>
</tr>
<tr>
<td></td>
<td>β</td>
<td>0.000770</td>
<td>-0.003052 - 0.001541</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beverton-Holt</td>
<td>α</td>
<td>564.7</td>
<td>-74423355 - 1067.6</td>
<td>0.994</td>
<td>565</td>
<td>13,400</td>
<td>-67.055</td>
<td>0.358</td>
</tr>
<tr>
<td></td>
<td>β</td>
<td>719.7</td>
<td>-99999856 - 1413.4</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Smooth hockey stick</td>
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<td>6.0181</td>
<td>-49.5620 - 8.1122</td>
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<td>411</td>
<td>2,544</td>
<td>-67.000</td>
<td>0.357</td>
</tr>
<tr>
<td></td>
<td>β</td>
<td>0.7550</td>
<td>-0.9539 - 1.0452</td>
<td></td>
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</tr>
</tbody>
</table>
**Method 1: Productivity Data Adjusted for Density Dependence**

Analysis of supplementation effects on productivity (adult recruits/spawner adjusted for density-dependent effects based on the smooth hockey stick model) using difference scores indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 25; Figure 16). All tests, regardless of treatment-reference pairs, indicated that productivity did not change significantly during the supplementation period, even though productivity did decrease during the supplementation period (Figure 16). These results are consistent with those based on unadjusted productivity data (Table 17). This is because most abundance estimates were below the level of assumed density dependence.

**Table 25.** Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data corrected for density dependence. Tests determined if the mean difference scores during the supplementation period were greater than mean difference scores during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.904</td>
<td>0.190</td>
<td>0.496</td>
</tr>
<tr>
<td>Marsh</td>
<td>-0.203</td>
<td>0.579</td>
<td>0.152</td>
</tr>
<tr>
<td>Sesech</td>
<td>1.607</td>
<td>0.071</td>
<td>1.435</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.431</td>
<td>0.335</td>
<td>0.147</td>
</tr>
<tr>
<td><strong>LN Productivity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>0.570</td>
<td>0.290</td>
<td>0.083</td>
</tr>
<tr>
<td>Marsh</td>
<td>0.012</td>
<td>0.495</td>
<td>0.003</td>
</tr>
<tr>
<td>Sesech</td>
<td>1.463</td>
<td>0.087</td>
<td>0.343</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.390</td>
<td>0.351</td>
<td>0.060</td>
</tr>
</tbody>
</table>
Figure 16. Mean differences (Treatment – Reference; figures on the top) and mean ratios (Treatment/Reference; figures on the bottom) of transformed and untransformed productivity data (adjusted for density dependence) before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Analysis of supplementation effects on productivity (adult recruits/spawner adjusted for density-dependent effects) using ratios indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 26; Figure 16). The Aspin-Welch test and the 95% CIs did indicate a significant effect when comparing the Chiwawa to the Marsh Creek population. These results are consistent with those using unadjusted productivity data (Table 20). Again, this is because most abundance estimates were below the level of assumed density dependence.

Table 26. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data corrected for density dependence. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>-0.529</td>
<td>0.696</td>
<td>0.087</td>
</tr>
<tr>
<td>Marsh</td>
<td>2.236</td>
<td>0.022</td>
<td>0.814</td>
</tr>
<tr>
<td>Sesech</td>
<td>0.677</td>
<td>0.253</td>
<td>0.191</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>0.033</td>
<td>0.487</td>
<td>0.018</td>
</tr>
<tr>
<td><strong>LN Productivity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>-0.621</td>
<td>0.726</td>
<td>0.104</td>
</tr>
</tbody>
</table>
Our analyses assume that there is a spawner abundance ($K_{sp}$) at which density-independent effects end and density-dependent effects begin. In reality, density-dependent effects occur at low spawning abundance and intensify as spawning abundance increases (evident in the changing slope of the three stock-recruitment curves used in our analyses). We did not account for these increasing density-dependent effects at spawner abundances less than $K_{sp}$. If we accounted for the increasing effects of density dependence at spawning abundances less than $K_{sp}$, the analysis with and without productivity adjustments may give different results.

**Method 2: Fraction of Carrying Capacity Filled with NORs**

We analyzed the effects of supplementation on filling the capacity of the habitat with natural-origin recruits. The smooth hockey stick model derived the carrying capacity ($K_R$) estimates for the Chiwawa and reference populations. The fraction of the carrying capacity filled with Chinook recruits before and during supplementation for the Chiwawa and reference populations is provided in Table 27. These data indicate that for the Chiwawa population, the mean fraction of the $K_R$ filled with fish decreased significantly from the pre-supplementation period through the supplementation period (Table 27). Likewise, the Entiat and Little Wenatchee populations showed a significant decline in the mean fraction of $K_R$ filled with adult recruits. In contrast, the mean fraction of $K_R$ in the Naches and Marsh Creek populations increased during the same period (Table 27). Interestingly, the fraction of $K_R$ filled with adult recruits for all populations trended downward during the pre-supplementation period (Figure 17). During the supplementation period, however, the fraction of $K_R$ filled with adult recruits trended upward for all populations. These results suggest that agents of mortality outside the Chiwawa and reference populations were reducing recruitment to the populations.

---

21 Although we do not show the results here, statistical analysis of the mean fraction of carrying capacity filled by adult recruits using natural-log transformed data produced the same result as using untransformed data. This was true for all populations.
Table 27. Fraction of the carrying capacity that was filled with Chinook salmon adult recruits in the Chiwawa and reference populations before (pre) and during (post) supplementation in Chiwawa Basin. The smooth hockey stick model estimated carrying capacity for each population. Statistical results from comparing the pre and post mean scores using the Aspin-Welch unequal-variance test are provided at the bottom of the table.

<table>
<thead>
<tr>
<th>Supplementation period</th>
<th>Chiwawa</th>
<th>Reference populations</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Naches</td>
<td>Entiat</td>
<td>Marsh</td>
<td>L. Wenatchee</td>
</tr>
<tr>
<td>Pre-supplementation period (1981-1992)</td>
<td>2.11</td>
<td>2.38</td>
<td>1.07</td>
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</tr>
<tr>
<td></td>
<td>1.53</td>
<td>1.93</td>
<td>1.20</td>
<td>0.75</td>
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</tr>
<tr>
<td></td>
<td>1.20</td>
<td>1.32</td>
<td>2.60</td>
<td>0.78</td>
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</tr>
<tr>
<td></td>
<td>1.14</td>
<td>1.19</td>
<td>0.49</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.99</td>
<td>1.06</td>
<td>0.46</td>
<td>0.34</td>
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</tr>
<tr>
<td></td>
<td>0.70</td>
<td>2.30</td>
<td>1.43</td>
<td>0.56</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>0.65</td>
<td>0.58</td>
<td>0.74</td>
<td>0.34</td>
<td>0.20</td>
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<tr>
<td></td>
<td>0.95</td>
<td>1.88</td>
<td>1.34</td>
<td>1.40</td>
<td>0.36</td>
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<tr>
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<td>0.18</td>
<td>0.72</td>
<td>1.63</td>
<td>0.22</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>0.27</td>
<td>0.45</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0.20</td>
<td>0.21</td>
<td>0.03</td>
<td>0.01</td>
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<tr>
<td>Pre-Mean:</td>
<td>0.86</td>
<td>0.99</td>
<td>1.24</td>
<td>0.76</td>
<td>0.37</td>
</tr>
<tr>
<td>Pre-Range:</td>
<td>0.00 – 2.11</td>
<td>0.20 – 2.30</td>
<td>0.21 – 2.38</td>
<td>0.02 – 2.60</td>
<td>0.01 – 0.78</td>
</tr>
<tr>
<td>Post-supplementation period (1992-2002)</td>
<td>0.05</td>
<td>0.98</td>
<td>0.34</td>
<td>0.41</td>
<td>0.03</td>
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<tr>
<td></td>
<td>0.15</td>
<td>0.86</td>
<td>0.41</td>
<td>1.13</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>0.04</td>
<td>0.35</td>
<td>0.27</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>0.44</td>
<td>0.30</td>
<td>0.02</td>
<td>0.03</td>
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<tr>
<td></td>
<td>0.19</td>
<td>4.39</td>
<td>0.65</td>
<td>0.45</td>
<td>0.06</td>
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<tr>
<td></td>
<td>0.82</td>
<td>2.68</td>
<td>1.85</td>
<td>2.78</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>0.31</td>
<td>2.37</td>
<td>1.65</td>
<td>4.10</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>0.01</td>
<td>0.53</td>
<td>0.42</td>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>0.71</td>
<td>1.62</td>
<td>0.82</td>
<td></td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>0.28</td>
<td>1.35</td>
<td>0.93</td>
<td></td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>0.27</td>
<td>0.83</td>
<td>0.98</td>
<td></td>
<td>0.18</td>
</tr>
<tr>
<td>Post-Mean:</td>
<td>0.26</td>
<td>1.49</td>
<td>0.78</td>
<td>1.27</td>
<td>0.08</td>
</tr>
<tr>
<td>Post-Range:</td>
<td>0.04 – 0.82</td>
<td>0.35 – 4.39</td>
<td>0.30 – 1.85</td>
<td>0.02 – 4.10</td>
<td>0.02 – 0.22</td>
</tr>
</tbody>
</table>

One-sided Aspin-Welch t-test of pre and post means

<table>
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<th></th>
<th>t</th>
<th>P</th>
<th>t</th>
<th>P</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.846;</td>
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<td>-0.967;</td>
<td>0.825</td>
<td>1.833;</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>3.321;</td>
<td>0.003</td>
<td>-0.799;</td>
<td>0.776</td>
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</tr>
</tbody>
</table>
We then compared the mean difference scores and ratios between the Chiwawa and reference populations before and during supplementation using data representing the fraction of $K_R$ filled with adult recruits. In most of the Chiwawa-reference population comparisons, the absolute value of the mean difference between the fraction of $K_R$ filled with recruits was greater in the supplementation period than during the pre-supplementation period; two of the four pairings were significant (Table 28; Figure 18). Analysis of difference scores using natural-log transformed data indicated that three of the four pairings were significant (Table 28).

Results from analyses using ratios were similar to results using difference scores. Mean ratio scores were generally smaller during the supplementation period than during the pre-supplementation period (Figure 18). This indicated that the mean fraction of $K_R$ filled by adult recruits in most reference populations was greater during the supplementation period than during the pre-supplementation period (i.e., the denominator in the ratio increased between the pre- and post-supplementation periods). In contrast, the fraction of $K_R$ filled by adult recruits in the Chiwawa decreased from the pre- to post-supplementation period (i.e., the numerator in the ratio decreased between the pre- and post-supplementation periods). Thus, unlike the Chiwawa population, the capacity of most reference populations was becoming more saturated during the period when the Chiwawa was being supplemented. Statistical analysis with mean ratios indicated that two of the four pairings were significant (Table 29).

Analyses comparing the Little Wenatchee with the Chiwawa indicate that adult recruits to the Little Wenatchee have been well below its carrying capacity. During the pre-supplementation period, the capacity of the Little Wenatchee was on average 37% saturated with adult recruits. During the supplementation period, the capacity of the Little Wenatchee declined to 8%
saturation with adult recruits (a 22% decline). The Chiwawa, during the pre-supplementation period, was on average 86% saturated. During the supplementation period, percent saturation in the Chiwawa decreased to 26% (a 30% decrease). During the same time periods, the capacity of the Entiat population, which until recently has been supplemented, declined from 124% to 78% saturation (a 63% decline).

**Table 28.** Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on the fraction of the habitat capacity ($K_R$) that is filled with natural origin recruits. Analyses include both transformed and untransformed data. Tests determined if the mean difference scores during the supplementation period were greater than mean difference scores during the pre-supplementation period.
**Figure 18.** Mean differences (Treatment – Reference; figures on the top) and mean ratios (Treatment/Reference; figures on the bottom) of transformed and untransformed fractions of carrying capacity filled with adult recruits before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin.

**Table 29.** Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on the fraction of the habitat capacity ($K_R$) that is filled with natural origin recruits. Analyses include both transformed and untransformed data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

<table>
<thead>
<tr>
<th>Reference population</th>
<th>Aspin-Welch unequal-variance test</th>
<th>Randomization test</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td>P-value</td>
<td>Effect size</td>
</tr>
<tr>
<td><strong>Fraction of Capacity Filled</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>1.317</td>
<td>0.119</td>
<td>0.217</td>
</tr>
<tr>
<td>Entiat</td>
<td>2.449</td>
<td>0.013</td>
<td>0.321</td>
</tr>
<tr>
<td>Marsh</td>
<td>2.001</td>
<td>0.035</td>
<td>0.905</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-1.148</td>
<td>0.864</td>
<td>0.791</td>
</tr>
<tr>
<td><strong>LN Fraction of Capacity Filled</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naches</td>
<td>1.257</td>
<td>0.127</td>
<td>0.207</td>
</tr>
<tr>
<td>Entiat</td>
<td>2.346</td>
<td>0.016</td>
<td>0.313</td>
</tr>
<tr>
<td>Marsh</td>
<td>1.737</td>
<td>0.056</td>
<td>0.729</td>
</tr>
<tr>
<td>Little Wenatchee</td>
<td>-1.525</td>
<td>0.924</td>
<td>0.815</td>
</tr>
</tbody>
</table>
Comparing Stock-Recruitment Curves

As a final set of treatment and reference population comparisons, we compared the stock-recruitment curves of the Chiwawa population (using \{R, S\} data only from the supplementation period) to the reference populations (using all available \{R, S\} data). Specifically, we tested whether the regression parameters were equal between the Chiwawa population and the reference populations, and whether the fitted curves coincided between populations. Earlier in this report we described the data, methods, and results of fitting the Ricker, Beverton-Holt, and smooth hockey stick curves to the data. Because AICc was unable to identify a best approximating model, here we included all three models in our analyses. We tested the following hypotheses.

Parameter equivalence:

Ho: Stock-recruitment parameters (\(\alpha\) and \(\beta\)) of the Chiwawa population = Stock-recruitment parameters of the reference populations.

Ha: Stock-recruitment parameters (\(\alpha\) and \(\beta\)) of the Chiwawa population \(\neq\) Stock-recruitment parameters of the reference populations.

Curve equivalence:

Ho: Modeled stock-recruitment curves of the Chiwawa population = Modeled stock-recruitment curves of the reference populations.

Ha: Modeled stock-recruitment curves of the Chiwawa population \(\neq\) Modeled stock-recruitment curves of the reference populations.

We used two-sided randomization tests to test the null hypotheses of equal model parameters and that fitted curves coincided. Because the total number of permutations was in the millions, we used a Monte Carlo approach to randomly select 10,000 permutations. The test statistic for comparing the model parameters was formed by summing the difference between the population parameter estimates for each pair of populations. The test statistic for comparing the whole curve was formed by summing the difference between the estimated predicted values for each pair of populations at 500 equally spaced points along the curve.

*Ricker Relationships*

Ricker curves differed significantly between the Chiwawa and reference populations (Figure 19; Table 30). Interestingly, however, the parameters in the Ricker model did not differ significantly among most populations (Table 30). Only the \(\beta\) parameter differed significantly between the Chiwawa and Entiat populations.

In the Ricker model, the \(\alpha\) parameter represents intrinsic productivity (i.e., recruits per spawner at low spawner densities). In this analysis, there was not enough evidence in the stock-recruitment data to reject the hypothesis of inequality in intrinsic productivity. Thus, this test was unable to demonstrate that supplementation, based on the Ricker curve, affected productivity in the Chiwawa population.
Figure 19. Scatter plot of the number of spawners and natural log adult recruits and fitted Ricker curves to the Chiwawa (supplemented population) and reference (un-supplemented) populations.

Table 30. Randomization test results comparing the equality of Ricker curves and equality of parameter values (α and β). Randomization tests were based on 10,000 Monte Carlo samples. Equality of curves was based on 500 points along the x-axis (spawner abundance axis).

<table>
<thead>
<tr>
<th>Curves tested</th>
<th>Curve inequality randomization P-value</th>
<th>Parameter inequality</th>
<th>Model Parameter</th>
<th>Randomization P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chiwawa</td>
<td>Reference</td>
</tr>
<tr>
<td>Chiwawa v. Naches</td>
<td>0.008</td>
<td>α = 1.2247</td>
<td>α = 2.5267</td>
<td>0.236</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β = 0.0015</td>
<td>β = 0.0010</td>
<td>0.600</td>
</tr>
<tr>
<td>Chiwawa v. Entiat</td>
<td>0.004</td>
<td>α = 1.2247</td>
<td>α = 1.5836</td>
<td>0.978</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β = 0.0015</td>
<td>β = 0.0035</td>
<td>0.025</td>
</tr>
<tr>
<td>Chiwawa v. Marsh</td>
<td>0.034</td>
<td>α = 1.2247</td>
<td>α = 1.1855</td>
<td>0.997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β = 0.0015</td>
<td>β = 0.0018</td>
<td>0.688</td>
</tr>
<tr>
<td>Chiwawa v. Sesech</td>
<td>0.036</td>
<td>α = 1.2247</td>
<td>α = 1.6818</td>
<td>0.972</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β = 0.0015</td>
<td>β = 0.0015</td>
<td>0.997</td>
</tr>
<tr>
<td>Chiwawa v. L. Wenatchee</td>
<td>0.034</td>
<td>α = 1.2247</td>
<td>α = 0.7439</td>
<td>0.969</td>
</tr>
<tr>
<td></td>
<td></td>
<td>β = 0.0015</td>
<td>β = 0.0008</td>
<td>0.203</td>
</tr>
</tbody>
</table>
Beverton-Holt Relationships

Beverton-Holt curves differed significantly only between the Chiwawa and Naches populations (Figure 20; Table 31). There was no significant difference in curves between the Chiwawa and the other reference populations. The parameters in the Beverton-Holt model did not differ significantly among any of the populations (Table 31). This was true even for the Chiwawa and Naches populations.

Figure 20. Scatter plot of the number of spawners and natural log adult recruits and fitted Beverton-Holt curves to the Chiwawa (supplemented population) and reference (un-supplemented) populations.

Table 31. Randomization test results comparing the equality of Beverton-Holt curves and equality of parameter values ($\alpha$ and $\beta$). Randomization tests were based on 10,000 Monte Carlo samples. Equality or curves was based on 500 points along the x-axis (spawner abundance axis).
Curves tested | Curve inequality randomization P-value | Parameter inequality
--- | --- | ---
Chiwawa v. Sesech | 0.272 | $\alpha = 264.25$ | $\alpha = 689.31$ | 0.821
 | | $\beta = 113.79$ | $\beta = 351.59$ | 0.869
Chiwawa v. L. Wenatchee | 0.654 | $\alpha = 264.25$ | $\alpha = 568.69$ | 0.864
 | | $\beta = 113.79$ | $\beta = 725.87$ | 0.751

**Smooth Hockey Stick Relationships**

Smooth hockey stick curves differed significantly between the Chiwawa and Naches populations and the Chiwawa and Sesech populations (Figure 21; Table 32). There was no significant difference in curves between the Chiwawa and the other reference populations. Most of the parameters in the smooth hockey stick model did not differ significantly among the populations (Table 32). However, the productivity parameter $\beta$ did differ significantly between the Chiwawa and the Naches and the Chiwawa and Little Wenatchee populations. The $\beta$ parameter for the Naches was significantly greater than the Chiwawa, while the $\beta$ parameter for the Little Wenatchee was significantly less than the Chiwawa.

![Smooth Hockey Stick Relationships](image)

**Figure 21.** Scatter plot of the number of spawners and natural log adult recruits and fitted smooth hockey stick curves to the Chiwawa (supplemented population) and reference (un-supplemented) populations.
**Table 32.** Randomization test results comparing the equality of smooth hockey stick curves and equality of parameter values ($\alpha$ and $\beta$). Randomization tests were based on 10,000 Monte Carlo samples. Equality of curves was based on 500 points along the x-axis (spawner abundance axis).

<table>
<thead>
<tr>
<th>Curves tested</th>
<th>Curve inequality randomization P-value</th>
<th>Parameter inequality</th>
<th>Randomization P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Model Parameter</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chiwawa</td>
<td>Reference</td>
</tr>
<tr>
<td>Chiwawa v. Naches</td>
<td>0.000</td>
<td>$\alpha = 5.41$</td>
<td>$\alpha = 6.61$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\beta = 1.84$</td>
<td>$\beta = 5.99$</td>
</tr>
<tr>
<td>Chiwawa v. Entiat</td>
<td>0.999</td>
<td>$\alpha = 5.41$</td>
<td>$\alpha = 5.05$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\beta = 1.84$</td>
<td>$\beta = 2.17$</td>
</tr>
<tr>
<td>Chiwawa v. Marsh</td>
<td>0.999</td>
<td>$\alpha = 5.41$</td>
<td>$\alpha = 5.56$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\beta = 1.84$</td>
<td>$\beta = 1.27$</td>
</tr>
<tr>
<td>Chiwawa v. Sesech</td>
<td>0.000</td>
<td>$\alpha = 5.41$</td>
<td>$\alpha = 6.15$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\beta = 1.84$</td>
<td>$\beta = 1.80$</td>
</tr>
<tr>
<td>Chiwawa v. L. Wenatchee</td>
<td>0.990</td>
<td>$\alpha = 5.41$</td>
<td>$\alpha = 6.02$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\beta = 1.84$</td>
<td>$\beta = 0.75$</td>
</tr>
</tbody>
</table>

Comparing different stock-recruitment curves and their parameters did not provide strong evidence that the supplementation program has negatively affected the productivity of the Chiwawa population.
Analysis without Reference Populations

In some cases, suitable reference populations may not exist to compare with supplemented populations. It is therefore important to have alternative analyses to assess supplementation effects. In this section, we describe methods that can be used to assess supplementation effects when suitable reference populations are not available. We discuss before-after comparisons, correlation analysis, and comparisons to standards as alternatives when reference populations are unavailable.

**Before-After Comparisons**

Before-after analyses compare population metrics (spawner abundance, NORs, and productivity) before supplementation to those during supplementation. In this case, data collected before supplementation represent the reference condition. The assumption is that population trajectories measured during the pre-supplementation period would continue in the absence of supplementation. We compared trends in abundance and productivity, mean abundance and productivity, and stock-recruitment relationships before and after supplementation.

*Trend Analysis*

Comparing trends before and after supplementation can be used to assess the effects of supplementation. Here, we compared the slopes of trends of spawner abundance, NORs, and productivity before and during supplementation using t-tests. If the hatchery program is successfully supplementing the natural spring Chinook population, the trend for spawner abundance and NORs during supplementation should be greater than the slope during the pre-supplementation period. For productivity, the slope during the supplementation period should increase or remain the same as that during the pre-supplementation period.

Visual examination of trends of Chiwawa data indicates that spawner abundance, NORs, and productivity decreased during the pre-supplementation period, but increased during the supplementation period (Figure 22). Only the changes in NOR trends were significant (Figure 22). This was true for both transformed and untransformed data.
Figure 22. Trends in Chiwawa spring Chinook spawner abundance, natural-origin recruits (NORs), productivity (adults recruits per spawner), and adjusted productivity (adjusted for density dependence) before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left show untransformed data; figures on the right include natural-log transformed data. Figures include results of t-tests comparing slope of trends before and during supplementation.
Analysis of Mean Scores

We also compared mean spawner abundance, NORs, and productivity data before and after supplementation. If the hatchery program is successfully supplementing the natural spring Chinook population, mean spawner abundance and NORs during the supplementation period should be greater than the pre-supplementation period. For productivity, the mean productivity during the supplementation period should be equal to or higher than the pre-supplementation period. We tested the following statistical hypotheses.

Spawner Abundance and NORs:

Ho: Mean spawner abundance and NORs before supplementation ≥ Mean spawner abundance and NORs during supplementation.

Ha: Mean spawner abundance and NORs before supplementation < Mean spawner abundance and NORs during supplementation.

Productivity (Recruits/Spawner):

Ho: Mean productivity before supplementation ≤ Mean productivity during supplementation.

Ha: Mean productivity before supplementation > Mean productivity during supplementation.

We tested before-after supplementation effects using a one-tailed Aspin-Welch unequal-variance test. We also used a randomization test, based on 10,000 Monte Carlo simulations, to assess differences in spawner abundance and productivity before and during supplementation. The randomization procedure only allowed the testing of two-tailed hypotheses. Therefore, we generated 95% confidence intervals on the mean difference ($\mu_{pre} - \mu_{post}$) using bootstrapping methods to determine if the significant result from the randomization test was in the right direction. We generated 5,000 bootstrap samples to calculate confidence intervals.

Mean spawner abundance during the supplementation period was significantly less than the pre-supplementation spawner abundance (Table 33). Mean spawner abundance decreased 46% between the pre- and post-supplementation periods. Likewise, mean NORs decreased significantly between the two periods (Table 33). On the other hand, productivity increased slightly, but not significantly, between the pre- and post-supplementation periods (Table 33). This was true for both adjusted and transformed productivity data.
Table 33. Statistical results comparing mean scores of spawner abundance, natural-origin recruits (NORs), and productivity (using both untransformed and natural-log transformed) before and during supplementation of Chiwawa spring Chinook. Randomization tests were based on 10,000 Monte Carlo samples and 95% CI were based on 5,000 bootstrap samples.

<table>
<thead>
<tr>
<th>Population metric</th>
<th>Mean scores</th>
<th>Test on means</th>
<th>Aspin-Welch test</th>
<th>Random test P-value</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>During</td>
<td>t-value</td>
<td>P-value</td>
<td>Before</td>
</tr>
<tr>
<td>Abundance</td>
<td>856</td>
<td>393</td>
<td>2.383</td>
<td>0.986</td>
<td>0.028</td>
</tr>
<tr>
<td>LN Abundance</td>
<td>6.6</td>
<td>5.4</td>
<td>3.304</td>
<td>0.997</td>
<td>0.004</td>
</tr>
<tr>
<td>NORs</td>
<td>905</td>
<td>275</td>
<td>2.846</td>
<td>0.993</td>
<td>0.009</td>
</tr>
<tr>
<td>LN NORs</td>
<td>6.0</td>
<td>5.0</td>
<td>1.197</td>
<td>0.876</td>
<td>0.250</td>
</tr>
<tr>
<td>Productivity</td>
<td>1.13</td>
<td>1.56</td>
<td>-0.721</td>
<td>0.759</td>
<td>0.479</td>
</tr>
<tr>
<td>LN Productivity</td>
<td>0.64</td>
<td>0.75</td>
<td>-0.450</td>
<td>0.671</td>
<td>0.649</td>
</tr>
<tr>
<td>Adj Productivity</td>
<td>1.12</td>
<td>1.56</td>
<td>-0.721</td>
<td>0.759</td>
<td>0.477</td>
</tr>
<tr>
<td>LN Adj Productivity</td>
<td>0.64</td>
<td>0.75</td>
<td>-0.450</td>
<td>0.671</td>
<td>0.652</td>
</tr>
</tbody>
</table>

Analysis of Stock-Recruitment Curves

The third method compared stock-recruitment curves of the Chiwawa population during supplementation with those generated before supplementation. Specifically, we tested whether the regression parameters were equal between the pre- and post-supplementation periods, and whether the fitted curves coincided between the two time periods. We used the methods described earlier to fit the Ricker, Beverton-Holt, and smooth hockey stick curves to the two data sets. We tested the following hypotheses.

Parameter equivalence:

Ho: Stock-recruitment parameters (α and β) of the pre-supplementation period = Stock-recruitment parameters of the supplementation period.

Ha: Stock-recruitment parameters (α and β) of the pre-supplementation period ≠ Stock-recruitment parameters of the supplementation period.

Curve equivalence:

Ho: Modeled stock-recruitment curves from the pre-supplementation period = Modeled stock-recruitment curves from the pre-supplementation period.

Ha: Modeled stock-recruitment curves from the pre-supplementation period ≠ Modeled stock-recruitment curves from the pre-supplementation period.

We were only able to fit stock-recruitment curves to the post-supplementation data. Non-linear regression was unable to converge on a solution using only pre-supplementation data. Therefore, we were unable to use this method to test supplementation effects on the Chiwawa spring Chinook population. If we could have fit curves to both the pre- and post-supplementation periods, we would have used two-sided randomization tests to evaluate the null hypotheses of equal model parameters and that fitted curves coincided.
Before describing correlation approaches, it is important to note that comparing before-after data can sometimes be misleading. For example, the spawner abundance, NORs, and productivity data presented in Figure 22 suggest that supplementation is increasing the abundance and productivity of spring Chinook in the Chiwawa Basin. However, when we compared these trends to those from reference populations during the same time periods (Figures 9-11), it becomes clear that supplementation was not responsible for increasing the trends in spawner abundance, NORs, and productivity of the Chiwawa population. Thus, whenever possible, it is wise to compare before-after data with a reference population.

**Correlation Analyses**

A simple way to see if the supplementation program is increasing or decreasing productivity is to assess the association between the proportion of adult spawners that are made up of hatchery adults (pHOS) and productivity (recruits/spawner). If the supplementation program is working as planned, the increase in hatchery fish spawning naturally should increase the productivity of the population. It should not decrease the productivity of the population.

We tested the association between pHOS and adult productivity\(^\text{22}\) using Pearson correlation. During the pre-supplementation period, productivity averaged 1.13 recruits/spawner; during the supplementation period, productivity averaged 1.39 recruits/spawner. This increase in productivity did not appear to be strongly correlated to pHOS (Figure 23). Correlation analysis showed that there was no significant association between pHOS and productivity, even though productivity increased with increasing pHOS.

\(^{22}\) Note that the analysis could also include juvenile productivity (e.g., smolts/spawner).
Figure 23. Association between the proportion of spawners that are made up of hatchery adults (pHOS) and the number of natural-origin recruits. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

The association between pHOS and productivity can also be assessed by testing the correlation between pHOS and the residuals from stock-recruitment curves fitted to the Chiwawa spawner and natural-origin recruitment data. This approach removes the effects of density dependence on the relationship between pHOS and productivity. A significant negative association provides evidence that hatchery-origin spawners may not be as productive as natural-origin spawners.

The Ricker, Beverton-Holt, and smooth hockey stick models were fit to the Chiwawa stock and recruitment data (including \{S, R\} data from both the pre- and post-supplementation period, 1981-2004) using methods described earlier. Residuals were calculated by subtracting the predicted recruitment values from the observed (modeled) values. Pearson correlation then tested the association between pHOS and the residuals from each model.

Although there was a negative trend in residuals with increasing pHOS, suggesting that hatchery-origin spawners may not be as productive as natural-origin spawners, the association was not significant (Figure 24). Thus, based on these analyses, there is no strong evidence that the supplementation program has significantly benefited or harmed the natural spring Chinook population.
Figure 24. Association between the proportion of spawners that are made up of hatchery adults (pHOS) and the residuals from Ricker, Beverton-Holt (B-H), and smooth hockey stick stock-recruitment models. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.
**Comparison to Standards**

In those cases in which suitable reference populations are not available and there are no pre-supplementation data, the investigator is left with comparing population parameters to relevant standards. Standards can include performance of natural-origin fish in similar environments (a type of reference condition), mitigation requirements, quantitative objectives of the program, Biological Assessment and Management Plan (BAMP) values, or other appropriate standards. An example of a statistical hypothesis would be:

\[
\begin{align*}
\text{Ho: } & \text{ Productivity (Recruits/Spawner) of the supplemented population } \geq \text{ standard productivity.} \\
\text{Ha: } & \text{ Productivity (Recruits/Spawner) of the supplemented population } < \text{ standard productivity.}
\end{align*}
\]

For these analyses to be useful, the standards must be based on biological reality.

**Conclusions and Recommendations**

Hatcheries are an important component of fish production within the Upper Columbia Basin. The goal of some of these programs is to supplement natural production in declining populations. The supplementation programs generally use both hatchery and natural (spawned and reared in nature from either wild or hatchery parents) adults for hatchery broodstock. These programs are designed to supplement natural populations by increasing natural reproduction while preventing the establishment of a domesticated hatchery stock. Thus, the programs should increase total spawning escapement and NORs, and not reduce the productivity of the natural population. Measuring the success of these programs is challenging and expensive.

In this paper, we described methods that can be used to determine if supplementation programs are achieving some of their goals. This paper focused on the use of reference populations to determine if the supplementation programs increase total spawning escapement, NORs, and maintain or increase productivities. In some cases, suitable reference populations may not be available (e.g., we found no suitable reference populations for Upper Columbia steelhead and sockeye). In these cases, alternative methods are needed to assess supplementation effects. We also described these alternative methods in this paper.

**Identification of Reference Populations**

Finding suitable reference populations that match well with supplemented populations is a difficult and time-consuming process. Our three-step selection process included identification of populations with similar life-history characteristics, few or no hatchery spawners, a long time series of accurate abundance and productivity estimates, and similar freshwater habitat impairments and out-of-basin effects. Those populations that met these criteria were then examined for their relationship with the supplemented population (in this case, the Chiwawa spring Chinook population). Several criteria were scored, including pNOS, correlation, trend, and effect size. Reference populations with total weighed scores of 81 or greater were selected as suitable reference populations.

This selection process provided a valuable framework for selecting suitable reference populations for supplemented populations. Interestingly, we found that a given reference population may match well with one parameter of the supplemented population (e.g., spawning
escapement), but not for all parameters (e.g., not NORs or productivity). The reason for this may be related to errors in the estimation of population parameters and/or differential factors limiting population parameters of supplemented and reference populations. Therefore, depending on the parameter analyzed, a different suite of reference populations may be needed.

An important assumption in the use of reference populations is that the supplemented and reference populations that tracked each other before supplementation would continue to track each other in the absence of supplementation. Given that the reference populations did not match the Chiwawa population on all criteria examined, and some reference populations tracked the Chiwawa population more poorly than others, there may be some uncertainty as to whether differences observed between the supplemented and reference populations during the supplementation period are associated with the hatchery program, or other unaccounted factors. For example, any large-scale change (man-made or natural) within the reference or supplemented population could affect our ability to assess the effectiveness of the supplementation program.

To account for some of these uncontrollable factors, we recommend the use of a “causal-comparative” approach to strengthen the certainty of our inferences. This approach relies on correlative data to try and make a case for causal inference. We recommend that the following state variables be measured and tracked within the supplemented and reference populations: mean annual precipitation, total and riparian forest cover, road density, impervious surface, and alluvium. These variables can be used to describe differences in water temperatures at different life stages (pre-spawning, egg incubation, and summer rearing) and substrate characteristics, including fine sediments and embeddedness. These state variables can be used to help explain possible changes in spawner abundance, NORs, and productivity that are independent of supplementation. In addition, the use of multiple reference streams reduces the possibility that man-made changes to a single reference stream will influence the interpretation of the results.

**Analyses with Reference Populations**

Using reference populations, we evaluated the effects of supplementation on natural-log transformed and untransformed total spawning escapement, NORs, and productivity by comparing trends, analyzing mean differences, ratios, and rates, and comparing stock-recruitment curves and their parameters. For trend analysis, we compared the slopes of the trends between each supplemented/reference pair before and during supplementation. If the hatchery program is successfully supplementing the natural population, trends in spawner abundance and NORs should deviate significantly during the supplementation period (i.e., the slope of the supplemented population should be greater than the slopes of the reference populations during the supplementation period), but not during the pre-supplementation period. For productivity, the slope of the supplemented population, relative to the reference population, should increase or remain the same.

Because trend analysis only tests the slopes of the trend lines, it does not test for differences in elevations of the trend lines, additional analyses were needed to determine if supplementation increased spawner abundance, NORs, and productivity of the target population without changing the slopes of the trend lines. To do this, we derived three different response variables using natural-log transformed and untransformed spawner abundance, NORs, and productivity data. The first derived variable included difference scores, which were calculated as the difference between paired treatment and reference data (T-R). The second included ratios, which were
calculated as the ratio of paired treatment and reference data (T/R). Finally, we calculated the differences in annual changes in paired treatment and reference population data (ΔT-ΔR). If the hatchery program is successfully supplementing the natural population, the mean difference or ratio score of paired spawner abundance data and NORs during the supplementation period should be greater than the pre-supplementation period. For productivity, the mean difference or ratio score during the supplementation period should be equal to or higher than the pre-supplementation period.

As a final set of analyses, we compared the stock-recruitment curves of the supplemented population (using stock and recruitment data only from the supplementation period) to the reference populations (using all available stock and recruitment data). Specifically, we tested whether the regression parameters were equal between the supplemented population and the reference populations, and whether the fitted curves coincided between populations. Here, we were most interested in comparing the productivity parameters in the models.

Surprisingly, these different analyses yielded similar results when they were applied to the Chiwawa spring Chinook and reference population data. Trend analysis was unable to detect a significant difference in trends between the supplemented and reference populations during the supplementation period. Even though we measured an increasing trend in spawner abundance, NORs, and productivity in the supplemented population during the supplementation period, these same parameters trended upward in the reference populations. Likewise, we were unable to detect a significant supplementation effect using difference scores, ratios, and differences in annual changes. However, we found the results from analysis of mean differences of annual change difficult to interpret and they may be insensitive to treatment effects. A simpler analysis, which is also easier to interpret, is to use trend analysis. Finally, comparing stock-recruitment curves and their parameters did not provide strong evidence that supplementation has affected the productivity of the natural population.

Based on these results, we do not recommend using difference scores of annual change (ΔT-ΔR), nor do we recommend comparing stock-recruitment curves and their parameters. As noted above, difference scores of annual change are difficult to interpret and may be redundant with trend analysis. Testing stock-recruitment curves and their parameters appears redundant with testing differences in productivity using difference scores or ratios. In addition, the analyses are computer intensive and do not appear to be very sensitive to changes.

There was little difference in results using difference scores and ratios. It appears that ratios may be more sensitive to change than difference scores (e.g., we found significant differences in some comparisons using ratios but not with difference scores), but ratios can be more difficult to interpret than difference scores. Nevertheless, we recommend the use of ratios in future analyses.
Correcting for Density Dependence and Carrying Capacity

The analyses described so far assumed that the density of spawners or recruits did not affect the survival and productivity of fish. However, without controlling for density effects, productivity of the population would continue to decline with increasing abundance. This scenario could occur in supplementation programs that increase the number of spawners, and could result in lower productivities relative to reference populations. In addition, lower productivities may be caused by differential environmental carrying capacities rather than the capacity of the supplemented fish to produce offspring. Therefore, we described two different methods for deriving density-corrected estimates of productivity. The first controlled the effects of density on productivity by partitioning observed productivities into density-independent and density-dependent productivity. These productivities were then combined in a single test. The second method corrected for differences in carrying capacities between the supplemented and reference populations. This was accomplished by calculating the percent saturation of NORs, which was estimated as the ratio of observed NORs to the maximum number of NORs that the habitat could support.

We fit Ricker, Beverton-Holt, and smooth hockey stick models to stock and recruitment data to estimate the maximum number of NORs (NORs at carrying capacity) and the maximum number of spawners needed to produce maximum NORs. We fit models to the supplemented and reference populations. Using information-theoretic criterion and evaluating the precision of estimated parameters, we found that the smooth hockey stick model provided the best estimates of maximum NORs and spawners. We used these modeled values to estimate density-independent and density-dependent productivities, and saturation of NORs.

Statistical analyses, using difference scores and ratios of adjusted Chiwawa spring Chinook productivity data, found no significant effects of supplementation on the productivity of the supplemented population. Indeed, the results from correcting for density dependence were similar to those without correcting for density dependence. This is in part because the abundance of the supplemented and reference populations has been below their respective carrying capacities in most years. This was clearly demonstrated in the analyses of NORs corrected for carrying capacity. In the supplemented population, the mean fraction of the carrying capacity filled with NORs decreased significantly during the supplementation period. In other words, the carrying capacity was filled with more NORs during the pre-supplementation period than during the supplementation period, which is contrary to the goal of supplementation. By comparison, two of the reference populations showed a similar decrease in saturation, while the other two reference populations actually increased in saturation. Analyzing the saturation scores using BACI-design analyses indicated that two of the four pairings differed significantly. That is, the percent saturation of the supplemented population decreased significantly relative to two reference populations.

Because productivity can be affected by the abundance of spawners and recruits, we recommend that future analyses comparing supplemented and reference populations adjust for density-dependent effects and differential carrying capacities. Although we detected only slight differences between adjusted and unadjusted results, as supplemented stocks recover, it will become more important to adjust productivities to account for density dependence. Importantly, the analyses using percent saturation placed NORs in the context of the carrying capacity of the environment. This will help managers determine if supplementation programs are filling or over-filling the capacity of the habitat with NORs.
As we noted earlier, analyses using productivities adjusted for density dependence assume that there is a spawner abundance at which density-independent effects end and density-dependent effects begin. In reality, density-dependent effects occur at low spawning abundance and intensify as spawning abundance increases. We did not account for these increasing density-dependent effects at lower spawner abundances. This is an area that needs additional attention.

Analyses without Reference Populations

Because of the rigorous criteria we used to select reference populations, it is likely that reference populations may not exist for making comparisons with supplemented populations. For example, we used the criteria described in this paper to identify reference populations for supplemented steelhead and sockeye populations in the Upper Columbia Basin. We were unsuccessful in identifying any suitable reference populations. Therefore, in the absence of suitable reference populations, it is important to have alternative methods for assessing supplementation effects. We described three different types of analyses one can use to assess supplementation effects in the absence of reference populations. They include before-after comparisons, correlation analysis, and comparisons to standards.

Before-after analyses compare population metrics before supplementation with those during supplementation. In this case, data collected before supplementation represent the reference condition. The assumption is that population trajectories measured during the pre-supplementation period would continue in the absence of supplementation. We compared trends in spawner abundance, NORs, and productivity before and after supplementation. In addition, we compared mean scores in these three parameters before and after supplementation. Finally, we attempted to compare stock-recruitment parameters before and after supplementation. The hypotheses examined were that the spawner abundance and NORs would be greater during the supplementation period, and that productivities would not decline during the supplementation period.

Trend analysis indicated that the all three Chiwawa spring Chinook population parameters trended downward during the pre-supplementation period, but trended upward during supplementation. On the other hand, mean spawner abundance and NORs were lower during the supplementation period than during the pre-supplementation period. Mean productivities increased, but not significantly, during the supplementation period. We were unable to compare pre- and post-supplementation stock-recruitment curves because we were unable to fit stock-recruitment models to the pre-supplementation data.

We used correlation analyses to determine if the proportion of hatchery-origin fish that spawn naturally on the spawning grounds (pHOS) increased productivity. In addition, we used correlation to assess the association between pHOS and the residuals from stock-recruitment relationships. A significant negative association provides evidence that hatchery-origin spawners may not be as productive as natural-origin spawners. The analysis indicated that the productivity of Chiwawa spring Chinook increased with increasing pHOS, but the association was not significant. In contrast, there was a negative association between pHOS and the stock-recruitment residuals, but again the association was not significant. The latter analysis accounts for density-dependent effects.

In concert, the before-after comparisons and correlation analyses do not provide conclusive evidence that the supplementation program has increased spawner abundance and NORs, or that it has significantly reduced the productivity of the supplemented population. Although increasing
the number of hatchery fish on the spawning grounds appears to reduce NORs and productivity, mean productivity actually increased during the supplementation period compared to the pre-supplementation period.

It is important to note that relying on only one set of analysis could result in drawing a wrong conclusion. For example, if we had only conducted trend analysis, we may have concluded wrongly that the Chiwawa spring Chinook supplementation program significantly increased spawner abundance, NORs, and productivity in the supplemented population. The analysis of mean scores and correlations indicates that the supplementation program has not increased spawner abundance or NORs in the supplemented population. Therefore, in the absence of suitable reference populations, we recommend that analyses include the evaluation of trends, means scores, and correlations. By conducting more than one set of analyses, one can use weight-of-evidence to assess the effects of supplementation programs.

Under the scenario that there are no reference populations or pre-supplementation data, one is left with comparing population parameters to relevant standards. These standards could come from mitigation requirements, quantitative objectives, or published or unpublished standards. One could also use correlation to evaluate the association between productivity and pHOS, but this requires a wide range in pHOS values to be most effective. A more extreme approach, which probably would not gain much traction with managers, is to shut off the supplementation program for some time and then evaluate the effects of the program in a before-after design. The Entiat spring Chinook hatchery program provides a unique opportunity to evaluate this type of management decision.

Some Concerns and Limitations

No matter how hard we try to explain different sources of variation in population data, we are limited by the quality of the data. Teasing out the effects of supplementation requires long time series of population data. Because funding levels and methods change over time, the quality (i.e., accuracy and precision) of the data also changes over time. Importantly, the population parameters examined in this paper (spawner abundance, NORs, and productivity) are rarely measured directly in the field. That is, other population metrics, such as numbers of redds, number of fish counted at weirs or dams, scales, tags, etc., are sampled in the field. These metrics are then used to calculate spawner abundance \(^{23}\), NORs, and productivity, often based on assumptions about fish/redd, pre-spawning loss, marking rates, and sampling rates. This has a tendency to increase the variability in the data independent of supplementation programs. In our studies, we can only control sampling within the supplemented populations, and even that is limited by available funding. We have no control over the sampling within reference populations. Thus, we have to assume that sampling within the reference populations will continue and that sampling effort will remain comparable to that in the supplemented populations.

In our analyses, we included both the Entiat and Little Wenatchee populations as references for the Chiwawa population. In the analyses, we treated them as equivalent to the other reference populations. That is, the statistical procedures used to compare the supplemented population to each reference population were identical. This is appropriate. However, the interpretation of the

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\(^{23}\) The smooth hockey stick model, which we used to estimate density-dependent correction factors for productivity and NORs, is sensitive to errors in spawner escapement estimates. Therefore, it is important to use accurate and precise estimates of spawner escapement.
results must be different when comparing the Entiat and Little Wenatchee to the supplemented population, because they are populations that were influenced by hatchery fish. As noted earlier, the Entiat spring Chinook hatchery program has been discontinued. Therefore, it provides a unique type of reference where the comparison changes from both populations being supplemented to only one population being supplemented. For the Little Wenatchee, nearly all the strays came from the Chiwawa program. Straying should stop or be greatly reduced with the change in water supply to the Chiwawa Rearing Ponds. In sum, one must be careful in how they interpret these test-reference results.

Finally, it is important to point out that for this paper, we conducted 463 statistical tests. Because we set our Type I error rate at 0.05, by random chance alone, we may have incorrectly rejected about 23 null hypotheses. Inasmuch as this work was designed to evaluate different ways to analyze test-reference data, the number of future analyses will be greatly reduced based on the results from this work. However, if the Type I error rate is a concern to managers, researchers can use a lower error rate, such as $\alpha = 0.01$. Another option is to analyze test-reference data graphically. Although this is subjective, there are no statistical analyses and therefore no concerns with violating assumptions of statistical tests, including temporal correlation. We believe researchers should use the statistical procedures recommended in this report to support graphic analysis.
References


APPENDIX C

ANNUAL M&E IMPLEMENTATION PLAN (MURDOCH AND SNOW 2012)
IMPLEMENTATION OF COMPREHENSIVE MONITORING AND EVALUATION OF DOUGLAS COUNTY PUD HATCHERY PROGRAMS IN 2012

Submitted to

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  and
Tom Kahler

Douglas County PUD

Submitted by

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November 2011
Introduction

The Douglas County PUD Monitoring and Evaluation Plan (M&E Plan; Wells HCP Hatchery Committee 2007) describes eight objectives specific to the hatchery programs funded by Douglas County PUD and two regional objectives that are related to artificial propagation. These same objectives have been identified in the M&E Plan for Chelan County PUD (Murdoch and Peven 2005) and are designed to address key questions regarding the use of supplementation as mitigation for mortality associated with the operation of Wells Hydroelectric Project. All objectives have specified indicators (i.e., primary) that will be measured and compared against target values established in the M&E Plan. Specific tasks and methodologies to be used in accomplishing the objectives are provided in the M&E Plan.

The primary focus of this proposal is the first eight objectives outlined in the M&E Plan, but additional regional objectives are included where warranted. Both disease (Objective 9) and non-target taxa risk assessment (Objective 10) have been identified as important components of the M&E Plan. The Hatchery Evaluation Technical Team (HETT) is currently addressing Objective 10. Objective 9 will be implemented once an experimental design has been developed and approved by the Wells HCP Hatchery Committee.

Successful implementation of the M&E Plan requires a continuation and potential expansion of existing relationships between the WDFW and other entities conducting similar field work in the Upper Columbia River Basin. Certain objectives require data to be collected from both target and reference populations. Field activities (i.e., data collection) not conducted by the WDFW, that are also required to implement the M&E Plan (i.e., reference populations) are not included in this proposal.

Addressing all the objectives within the M&E Plan will require multiple years of data collection. Several objectives may be adequately addressed after one year or five years (Table 1), and may require only periodic monitoring (e.g., every five or ten years). This proposal and budget encompasses one year of work in which WDFW will furnish all supervision, labor, services, materials, tools, and equipment necessary to implement the Monitoring and Evaluation Plan of hatchery programs funded by Douglas County PUD. All statistical analyses will be conducted consistent with the Analytical Framework for Monitoring and Evaluating PUD Hatchery Programs (Hays et al. 2007), or revised versions of that document as applicable.
Table 1. A potential long-term implementation schedule of objectives outlined in the Douglas County PUD M&E Plan.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Year of implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-4</td>
</tr>
<tr>
<td>1</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>X</td>
</tr>
<tr>
<td>9</td>
<td>Experimental design not complete</td>
</tr>
<tr>
<td>10</td>
<td>HETT is currently conducting this assessment</td>
</tr>
</tbody>
</table>

Reference Populations

Reference populations are a critical component of the M&E Plan (Goodman 2004; ISRP & ISAB 2005). The HETT has developed a methodology for assessing and choosing reference populations, and WDFW and Douglas PUD have incorporated reference population analyses for Spring Chinook under Objective 1 in the 2011 draft 5-year M&E report (submittal to the HCP Hatchery Committee is pending at this time). Reference populations for steelhead and summer Chinook have not been identified by the HETT due to lack of populations similar to target populations that have not been substantially supplemented, or because potentially suitable reference populations lack the required data sets. Future analyses of spring Chinook program/populations will be able to build from this initial work. However, it is unclear if suitable reference populations will be available for steelhead due to lack of data. For Wells Hatchery summer Chinook, identifying suitable reference populations is not necessary, since the program is focused on harvest augmentation and not supplementation.
WORK PLAN BY OBJECTIVE

Objective 1: Determine if a) supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population relative to a non-supplemented population(s) (i.e., reference population) and b) the changes in the natural replacement rate (NRR) of the supplemented population are similar to that of the non-supplemented population(s).

Hypotheses:

- $H_0_1$: Number of hatchery fish that spawn naturally > number of naturally and hatchery produced fish taken for broodstock.
- $H_a_1$: Number of hatchery fish that spawn naturally $\leq$ number of naturally and hatchery produced fish taken for broodstock.
- $H_0_2$: $\Delta$NOR/Max recruitment $\geq$ $\Delta$NOR/Max recruitment Non-supplemented population
- $H_a_2$: $\Delta$NOR/Max recruitment Supplemented population $<$ $\Delta$NOR/Max recruitment Non-supplemented population
- $H_0_3$: $\Delta$ NRR Supplemented population $\geq$ $\Delta$ NRR Non-supplemented population
- $H_a_3$: $\Delta$ NRR Supplemented population $<$ $\Delta$ NRR Non-supplemented population

General Approach

Spawning ground, broodstock, and harvest data (e.g., selective fisheries) will be the source of all abundance, composition, and productivity information required for this objective. Identification of suitable non-supplemented reference populations will be problematic in the Upper Columbia Basin because some species/races do not have populations that have not been either supplemented or influenced by hatchery fish, or do not have adequate data sets for analyses (see discussion, above). For those supplemented populations without a suitable spatial reference population, temporal references may be used (i.e., before-after hatchery intervention comparison). Temporal reference populations may also be initiated if deemed necessary, by discontinuing hatchery releases in a target population for a predetermined period of time (i.e., at least one generation minimum) to allow a before-after comparison.

Methodology

Standard spawning ground survey methodology outlined in Appendix F of the M&E Plan (Spawning ground surveys) and data analysis outlined in Appendix G of the M&E Plan (Relative Abundance) will be used under this objective. WDFW will coordinate with other Agencies (i.e., USFWS, USFS, Tribes) that conduct spawning ground surveys to ensure methodologies and sample rates are consistent with methodologies used in this objective (Table 2). Spawning/carcass surveys will be conducted for Methow Basin spring Chinook (WDFW); Methow Basin steelhead (WDFW); and Okanogan steelhead.
The use of a composite spring Chinook broodstock in the Methow and Chewuch Rivers suggests that the Methow and Chewuch spawning aggregates be treated as a single group. The combined group (i.e., MetChew) is supported by analysis of genetic data, which concluded that both spawning aggregates are very closely related (Snow et al. 2007). However, differences in spawner abundance and carrying capacity of the two subbasins may require that each subbasin be treated independently for data analysis purposes.

Table 2. Methodologies used to determine biological information used in Objective 1.

<table>
<thead>
<tr>
<th>Population</th>
<th>Spawning ground methodology</th>
<th>Spawner composition</th>
<th>Age composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow steelhead</td>
<td>Expanded index</td>
<td>Wells Dam</td>
<td>Wells Dam</td>
</tr>
<tr>
<td>Twisp steelhead</td>
<td>Total ground</td>
<td>Twisp weir</td>
<td>Twisp weir</td>
</tr>
<tr>
<td>Okanogan steelhead a</td>
<td>Total ground</td>
<td>Wells Dam</td>
<td>Wells Dam</td>
</tr>
<tr>
<td>Methow sp. Chinook</td>
<td>Total ground</td>
<td>Carcasses</td>
<td>Wells Dam</td>
</tr>
<tr>
<td>Chewuch sp. Chinook</td>
<td>Total ground</td>
<td>Carcasses</td>
<td>Wells Dam</td>
</tr>
<tr>
<td>Twisp sp. Chinook</td>
<td>Total ground</td>
<td>Carcasses</td>
<td>Wells Dam</td>
</tr>
</tbody>
</table>

a Conducted by CCT.

Schedule of Activities

Table 4. Schedule for conducting spawning ground surveys and data analysis (D = data collection; A = data analysis).

<table>
<thead>
<tr>
<th>Target population</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow/Okanogan steelhead</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Methow Basin spring Chinook</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

Analysis within the draft 5-year M&E Plan report identified low survival of hatchery- and natural-origin spring Chinook as a factor in the decrease in natural-origin spawner abundance and poor overall productivity of spring Chinook stocks. For 2012, we propose to increase PIT-tagging of wild spring Chinook parr in the Methow and Chewuch rivers in addition to ongoing PIT-tagging of wild steelhead and spring Chinook in the Methow Basin (Table 3). This tagging is expected to provide adequate sample sizes of wild spring Chinook to estimate migration survival through the Columbia River so that factors affecting survival can be identified. Fish collection for this tagging will be conducted via hook-and-line angling, seine or dip netting, electroshocking, trapping at irrigation ditch returns, or rescue from irrigation ditches or naturally de-watering areas via traps, nets, or electroshocking equipment. Additional effort for steelhead tagging conducted in the Twisp River will address sample size requirements for an on-going relative reproductive success study funded under BPA contract # 49080. Tagging methodologies will be consistent with ongoing activities in the Wenatchee and Entiat basins following protocols developed under the ISEMP.
Recommendations within the 5-year report suggest the Chewuch spring Chinook program be adjusted to rely on wild Chewuch-origin broodstock, or be discontinued. However, options to increase the number of locally adapted wild fish within the broodstock are limited. We propose to investigate alternative methods of collecting adult natural origin fish for inclusion in the Methow River and Chewuch River broodstocks using netting techniques, temporary picket-type weirs, or hook-and-line angling. Any adult fish collected would be incorporated into the Methow Hatchery spring Chinook program under the “Upper Columbia River Salmon and Steelhead Broodstock Objectives and Site-Based Broodstock Collection Protocols” developed annually prior to broodstock collection activities.

WDFW may assist DPUD in an assessment of subyearling summer Chinook life history by PIT-tagging up to 10,000 summer Chinook subyearlings in the Methow Basin.

Table 3. PIT-tagging goals for juvenile wild fish in the Methow Basin.

<table>
<thead>
<tr>
<th>Target population</th>
<th>Wild fish</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steelhead</td>
</tr>
<tr>
<td>Methow River</td>
<td>1,000</td>
</tr>
<tr>
<td>Twisp River</td>
<td>2,000a</td>
</tr>
<tr>
<td>Chewuch River</td>
<td>1,000</td>
</tr>
<tr>
<td>Misc. tributaries</td>
<td>1,000</td>
</tr>
<tr>
<td>Total</td>
<td>5,000</td>
</tr>
<tr>
<td>DPUD Contribution</td>
<td>3,500</td>
</tr>
</tbody>
</table>

*Includes 1,500 fish tagged and funded through BPA contract No. 49080.

Objective 2: Determine if the run-timing, spawn-timing, and spawning distribution of both the natural and hatchery components of the target population are similar.

Hypotheses:

- **Ho₄**: Migration timing {\text{Hatchery Age X = Migration timing}} Naturally produced Age X
- **Ha₄**: Migration timing {\text{Hatchery Age X \neq Migration timing}} Naturally produced Age X
- **Ho₅**: Spawn timing {\text{Hatchery = Spawn timing}} Naturally produced
- **Ha₅**: Spawn timing {\text{Hatchery \neq Spawn timing}} Naturally produced
- **Ho₆**: Redd distribution {\text{Hatchery = Redd distribution}} Naturally produced
- **Ha₆**: Redd distribution {\text{Hatchery \neq Redd distribution}} Naturally produced
General Approach

A properly integrated hatchery program produces fish that have life-history traits similar to naturally produced fish. Differences in any of these behavioral life history traits may affect progeny survival. Migration timing in the Columbia River of both juvenile and adult fish will be assessed using PIT tags when available. Migration timing into spawning tributaries will be assessed at broodstock-collection locations, or using in-stream PIT antenna arrays. In 2009, in-stream antenna arrays were installed in the lower Methow and Twisp rivers to assess the distribution and migration timing of adult hatchery and wild steelhead. These antennas, in conjunction with arrays installed by other researchers (i.e., USGS) will be used to assess steelhead and spring Chinook run timing and distribution throughout the Methow Basin.

Spawn timing and redd distribution data for spring Chinook will be collected during spawning-ground surveys. We propose selecting index reaches to evaluate spawn timing in reaches where similar proportions of hatchery and naturally produced fish are expected to spawn (based on carcass recovery data). The use of index reaches will eliminate any potential bias in spawn timing due to differences in spawning locations. Carcass recovery locations will be used as a surrogate for spawning location.

For summer steelhead, WDFW will conduct an evaluation in the Twisp River using visual observation of spawning fish to evaluate spawn timing and location. All fish sampled at the Twisp River weir in 2012 will be PIT-tagged and steelhead will also be externally Floy-tagged with origin- and sex-specific colors. Surveyors will conduct intensive surveys to quantify redd distribution and collect observational data from Floy-tagged fish. Adult female steelhead will be PIT-tagged in the body cavity to maximize the likelihood that PIT tags will be expelled into redds. Redds will be scanned with portable PIT-tag antennas to confirm the origin of females observed spawning, and to provide spawn timing information for redds where no visual observations of spawners were made. Further, temporary in-stream PIT antennas will be installed in selected Methow Basin tributaries to assess whether surveys are conducted in all spawning areas, and to estimate spawner abundance in areas where conducting systematic surveys is problematic (e.g., Lost River). Funding for increased spawning ground surveys, PIT tag monitoring, and Floy Tag detections above baseline Douglas PUD M&E activities will be funded by the Bonneville Power Association (BPA) through contracts 49080 and 47950.

Methodology

Migration Timing

As previously stated, when available, PIT tags will be used to evaluate differences in migration timing in the Columbia River. During broodstock collection activities at mainstem dams, tributary traps, and the Twisp River weir, PIT tags will be inserted in all fish captured and released so that data on migration timing to spawning tributaries can be collected (Table 5). Migration timing into spawning tributaries will be assessed using PIT antenna arrays deployed at long-term sites in the lower Methow and Twisp rivers,
utilizing antennas installed by other researchers within the Methow and Okanogan Basins (e.g., USGS), and using PIT antennas installed on a temporary basis in selected tributaries.

Table 5. Methods and locations used for evaluating differences in migration timing between hatchery and naturally produced salmon and steelhead.

<table>
<thead>
<tr>
<th>Target population</th>
<th>Migration timing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Columbia River(^a) Spawning tributary</td>
</tr>
<tr>
<td>Methow spring Chinook</td>
<td>Wells Dam, PIT tags, CWTs Twisp Weir, Chewuch PIT array</td>
</tr>
<tr>
<td>Methow steelhead</td>
<td>Wells Dam, PIT tags, VIE Twisp Weir, PIT arrays in select tribs</td>
</tr>
<tr>
<td>Okanogan steelhead</td>
<td>Wells Dam, PIT tags, Ad clip Omak Cr. Weir/Zosel Dam</td>
</tr>
</tbody>
</table>

\(^a\) PIT tags will be used when available (i.e., in conjunction with other objectives).

**Spawn Timing**

All spawn timing information necessary for evaluating differences between hatchery and naturally produced salmon and steelhead will be collected during spawning-ground surveys (M&E Plan Appendix F). Specific spawn timing information will only be collected within index spawning areas. Index areas identified are likely to have a similar proportion of hatchery and naturally produced fish spawning, based on carcass recoveries between 2003 and 2006 (Table 6). Carcass recovery date of female spring Chinook salmon will be compared to examine relative differences in spawn timing.

Determining the relative spawn timing of steelhead in the natural environment is problematic because not all hatchery fish are adipose fin-clipped. In 2012, an evaluation of steelhead spawn-timing in the Methow Basin will be conducted utilizing female steelhead Floy-tagged at the Twisp River weir. Floy tag colors will be alternated every other year between hatchery and wild fish to control for any potential color effects on reproductive success. In 2012, male and female hatchery fish will be tagged with pink and blue tags, respectively; and male and female wild fish with chartreuse and red tags, respectively. Approximately 85% of the steelhead in the Twisp River spawn upstream of the Twisp River weir (mean 2003-2005). Steelhead will be captured and tagged at the Twisp River weir between 1 March and 15 June. All fish captured will be examined to determine origin (VIE, PIT, CWT, or eroded fins), age, and PIT tags, and colored anchor tags will be applied depending on stock and origin. Surveyors will record the tag color and date of all female steelhead observed during surveys and record GPS locations of all redds. Surveyors will also record the incidence of non Floy-tagged fish upstream of the Twisp River weir to determine weir capture efficiency. Because redd residence time of steelhead can be very low, female steelhead will be PIT-tagged in the body cavity to encourage tag expulsion into the redd. Surveyors will periodically scan completed redds for PIT tags to confirm female origin, or to identify female origin for redds where no visual observations of spawners occurred. Sampling at the Twisp River weir will be accomplished in conjunction with an on-going relative
reproductive success study of steelhead in the Twisp River which receives funding through this implementation plan, and BPA contract No. 49080.

Table 6. Potential tributary index areas identified for each respective target population used for evaluating differences in spawn timing between hatchery and naturally produced salmon and steelhead.

<table>
<thead>
<tr>
<th>Target population</th>
<th>Historical reach(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twisp spring Chinook</td>
<td>Twisp River (T5 - T6)</td>
</tr>
<tr>
<td>Chewuch spring Chinook</td>
<td>Chewuch River (C4 - C6)</td>
</tr>
<tr>
<td>Methow spring Chinook</td>
<td>Methow River (M9 - M11)</td>
</tr>
<tr>
<td>Twisp steelhead</td>
<td>Twisp River (T4 - T10)</td>
</tr>
</tbody>
</table>

**Spawning Distribution**

Redd distribution data will also be collected during spawning ground surveys (M&E Plan Appendix F). The origin of spawners will be identified from carcasses (i.e., scales or CWT), and carcass recovery location (i.e., rkm) of female spring Chinook will be used to determine redd distribution. Overall steelhead redd distribution will be determined from GPS location information for each redd observed. Distribution by origin of spawning adult steelhead cannot be determined without application of an additional mark (e.g., Floy tag) because not all hatchery steelhead were adipose fin-clipped. Steelhead spawning distribution by origin of spawning adults will be assessed at the Twisp River weir in 2012. Surveys will be conducted at least weekly in the Twisp River to assess distribution of Floy-tagged females and to scan for PIT tags as previously described. Resident rainbow, residual hatchery steelhead, and cutthroat trout females will also be PIT-tagged in the body cavity to determine if these species or resident stages contribute to steelhead redd count estimates. Additionally, temporary in-stream PIT tag antenna arrays will be placed in selected tributaries to assist with spawning distribution evaluation. In conjunction with adult salmonid tagging at the Twisp weir and Wells and Priest Rapids Dams, these arrays are expected to provide a reliable, cost-effective means of corroborating current survey methodologies with observed salmonid use, and assessing spawning distribution (if any) in locations where spawning is presumed to not occur, or where surveys are difficult to conduct.

**Schedule of Activities**

Table 7. Schedule for conducting migration timing, spawn timing, and spawning distribution field activities and data analysis (D = data collection; A = data analysis).

<table>
<thead>
<tr>
<th>Target population</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow steelhead</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Methow spring Chinook</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>
Objective 3: Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in the phenotypic characteristics of natural populations.

Hypotheses related to the genetic diversity, population structure, and effective population size (Ho 7-9) were addressed in the 2008-2010 work plans and will not be addressed in 2012. The following hypotheses of age and size at maturity will be addressed in 2012:

- $H_{010}$: Age at Maturity $\text{Hatchery} = \text{Age at Maturity Naturally produced}$
- $H_{a10}$: Age at Maturity $\text{Hatchery} \neq \text{Age at Maturity Naturally produced}$
- $H_{011}$: Size (length) at Maturity $\text{Hatchery Age X and Gender Y} = \text{Size (length) at Maturity Naturally produced Age X and Gender Y}$
- $H_{a11}$: Size (length) at Maturity by age and gender $\text{Hatchery} \neq \text{Size (length) at Maturity by age and gender Naturally produced}$

General Approach

Genetic Assessment (not performed in 2012): Genotypes of hatchery and naturally produced populations will be sampled and monitored based upon the schedule outlined in Appendix H of the Douglas PUD M&E Plan. Priority of analysis was based upon recovery needs or relative risk a hatchery program may have on the naturally produced population.

Phenotypic Assessment: Differences in phenotypic characteristics that may arise as a result of hatchery programs (i.e., domestication) will be measured using historical (i.e., prior to current hatchery programs) and recent data collected from wild fish and broodstock or carcasses recovered on the spawning grounds. Data related to additional important phenotypic characteristics will be collected and analyzed as part of Objective 2 (e.g., run timing, spawn timing, and spawning location), Objective 4 (e.g., fecundity), and Objective 7 (e.g., size and age at smolt migration).

Methodology

Data for monitoring phenotypic characteristics (i.e., age at maturity and size at maturity) will be collected annually as part of the broodstock collection protocol (M&E Plan Appendix B), run assessment, and carcass recoveries. Broodstock for all programs are not collected randomly from the run at large with respect to sex, origin, or age. However, trapping activities do provide an opportunity to collect data from a random sample of the run-at-large (i.e., those fish collected during broodstock trapping and released upstream). Historically, information related to the spawning population was derived from broodstock, carcasses, or a combination of both. Recent data suggest that carcass recovery and broodstock methods are biased and additional sampling at sampling/broodstock collection sites (e.g. Wells Dam) is required (Zhou 2002; Murdoch 7).
Broodstock collection sites are located near or below a majority of the spawning locations (Table 8). All fish trapped, or a random sample depending on the stock, will be sampled to determine origin, age, and size. This will provide a sample that more accurately, in a less biased way, represents the population. Additionally, PIT tags may be inserted into adult fish released upstream of Wells Dam and the Twisp River weir to address other M&E Plan objectives (i.e., migration timing and spawning distribution, Objective 2; stray rates, Objective 5).

Table 8. Broodstock collection locations for stock assessment and phenotypic characterization of hatchery and naturally produced fish.

<table>
<thead>
<tr>
<th>Stock</th>
<th>Primary location</th>
<th>Secondary location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow Basin spring Chinook</td>
<td>Wells Dam</td>
<td>Twisp Weir</td>
</tr>
<tr>
<td>Methow/Okanogan steelhead</td>
<td>Wells Dam</td>
<td>Twisp Weir / Priest Rapids Dam</td>
</tr>
</tbody>
</table>

Schedule of Activities

Table 9. Schedule for conducting size and age at maturity comparisons (D = data collection; A = data analysis).

<table>
<thead>
<tr>
<th>Target population</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow/Okanogan steelhead</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Methow spring Chinook</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

Objective 4: Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate; HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate; NRR) and equal to or greater than the program specific expected value (BAMP 1998).

Hypotheses:

- $H_{012}$: $HRR_{Year x} \geq NRR_{Year x}$
- $H_{a12}$: $HRR_{Year x} < NRR_{Year x}$
- $H_{013}$: $HRR \geq BAMP$ value (preferred)
- $H_{a13}$: $HRR < BAMP$ value

General Approach

The survival advantage from the hatchery (i.e., egg-to-smolt) must be sufficient to overcome lower post-release survival (i.e., smolt-to-adult) in order to produce a greater number of returning adults than if broodstock were allowed to spawn naturally. If a hatchery program cannot produce a biologically significant greater number of adults than naturally spawning fish, the program should be modified or discontinued. More simply, the hatchery replacement rate should always be greater than the natural replacement rate.
Hatchery programs in the Upper Columbia River were initially designed based on observed mean survival rates for each stock (BAMP 1998). Performance of the hatchery programs will be assessed using those expected survival rates and the number of broodstock collected on a brood year basis. Harvest augmentation hatchery programs will only be compared to the expected HRR value because a corresponding NRR is not available or applicable (e.g., Wells summer Chinook).

Methodology

Smolt to adult (SAR) and HRR values will be calculated for each stock. SAR values are currently calculated using CWT recoveries from all locations (harvest, hatcheries, and spawning grounds), except for steelhead, for which SAR values are calculated based on sampling that occurs at Priest Rapids Dam or Wells Dam to obtain an estimate of the number of returning adults from the hatchery program. HRR values that fall below the expected values or the corresponding estimate of NRR (M&E Plan Appendix G) will be evaluated to determine whether in-hatchery (M&E Plan Appendix C) or out-of-hatchery (M&E Plan Appendix D) factors contributed to the reduced survival.

The 5-year M&E Plan analysis report noted that survival rates for hatchery and naturally-produced spring Chinook were lower than expected and increased PIT-tagging of both hatchery and wild fish was recommended to help identify survival constraints. For life-stage survival comparisons, stray rate monitoring, and assessment of migration patterns, rate, and speed within the basin, we propose that hatchery steelhead and spring Chinook be tagged at the Wells and Methow hatcheries prior to release (Table 10) for comparison to naturally produced fish (see Table 3). Comparison groups of hatchery spring Chinook and steelhead were historically tagged at each smolt trap, but tag rates were likely too low to provide meaningful comparisons. Further, PIT-tagging at the Methow smolt trap likely incorporated fish from hatchery programs not covered under the M&E Plan (i.e., WNFH) because release time and hatchery mark were often the same for steelhead and spring Chinook released from WDFW and USFWS hatcheries in the Methow Basin. Since releases of fish from these hatcheries have exhibited different survival rates (Townsend and Skalski 2004), tagging should occur at the hatcheries of origin to ensure that evaluations are conducted with target stocks.

Table 10. PIT-tagging goals for Douglas PUD hatchery fish released in 2013.

<table>
<thead>
<tr>
<th>Target population</th>
<th>Hatchery fish</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steelhead</td>
</tr>
<tr>
<td>Methow River</td>
<td>5,000</td>
</tr>
<tr>
<td>Twisp River</td>
<td>5,000</td>
</tr>
<tr>
<td>Chewuch River</td>
<td>0</td>
</tr>
<tr>
<td>Wells Hatchery</td>
<td>5,000</td>
</tr>
<tr>
<td>Douglas PUD total</td>
<td>15,000</td>
</tr>
</tbody>
</table>

<sup>a</sup> 6,000 PIT tags already proposed for 2012 through Yakama Nation multi-species acclimation project.
Schedule of Activities

Table 11. Schedule of activities for hatchery evaluation activities (D = data collection; A = data analysis).

<table>
<thead>
<tr>
<th>Target population</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow/Okanogan steelhead</td>
<td>A/D</td>
<td>A/D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Wells summer Chinook</td>
<td>A/D</td>
<td>A/D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Methow Basin spring Chinook</td>
<td>A/D</td>
<td>A/D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

Objective 5: Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation.

Hypotheses:

- \( \text{Ho}_{14} \): Stray rate of hatchery fish < 5% of total brood return
- \( \text{Ha}_{14} \): Stray rate of hatchery fish \( \geq \) 5% of total brood return
- \( \text{Ho}_{15} \): Stray hatchery fish < 5% of spawning escapement (based on run year) within other independent populations
- \( \text{Ha}_{15} \): Stray hatchery fish \( \geq \) 5% of spawning escapement (based on run year) within other independent populations
- \( \text{Ho}_{16} \): Stray hatchery fish < 10% of spawning escapement (based on run year) of any non-target streams within independent populations
- \( \text{Ha}_{16} \): Stray hatchery fish \( \geq \) 10% of spawning escapement (based on run year) of any non-target streams within independent populations

General Approach

Excessive strays from hatchery programs pose significant genetic risk (loss of genetic variation between populations) and must be monitored in order to determine the magnitude of the problem and develop reasonable and appropriate recommendations. Stray rates will be monitored using CWT recoveries from Chinook spawning ground surveys. The Regional Mark Information System (RMIS) database will provide all necessary CWT information needed when calculating stray rates for each brood year or within and outside basin stray rates based on spawning escapement estimates.

Brood year stray rates will require multiple-year CWT recoveries (i.e., all age classes) from broodstock and carcass recoveries on the spawning grounds. The estimated number of strays for the entire brood year will be calculated by dividing the number of strays by the total number of hatchery fish that returned. Stray rates within, and between independent populations will be calculated in a similar manner as brood year stray rates, except on an annual basis and based on the estimated spawning escapement.
Collecting stray rate information for steelhead poses the greatest challenge because carcasses are not available for examination. When available, radio tag information and/or adult PIT-tag monitoring may provide adequate information for evaluating stray rates. Some data needed for evaluating stray rates for the Methow/Okanogan steelhead will be collected during broodstock trapping activities at Wells Dam (M&E Plan Appendix B), and through operation of the Twisp River weir when assessing spawn-timing (see Objective 2). Stray rates in other tributaries may need to be calculated by other types of sampling (i.e., PIT tags, radio tags, hook-and-line, electroshocking) if warranted. Antenna arrays installed by WDFW and other researchers should provide tributary stray rate information, provided that adequate numbers of juvenile fish are PIT-tagged prior to release (hatchery fish) or within natal streams (wild fish). Tagging of hatchery steelhead under Objective 4 (see Table 10) should satisfy within-basin and out-of-basin stray rate monitoring goals of fish destined for release in the Methow Basin.

### Methodology

Stray rates will be calculated using procedures outlined in the spawning ground survey methodology (M&E Plan Appendix F). As stated previously, information needed to evaluate steelhead stray rates will be obtained during broodstock collection activities at Wells Dam, operation of the Twisp Weir and antenna array, and through other proposals. However, direct observations on the spawning grounds by other Agencies (e.g., USFWS, CCT, or USGS) or via PIT tags may be required in non-target streams (Table 12).

<table>
<thead>
<tr>
<th>Hatchery program</th>
<th>Target stream/release location</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twisp steelhead NNI</td>
<td>Twisp</td>
<td>PIT/Observation/creel(^a)</td>
</tr>
<tr>
<td>Methow steelhead safety-net</td>
<td>Methow Hatchery</td>
<td>PIT/Observation/creel(^a)</td>
</tr>
<tr>
<td>Wells steelhead safety-net</td>
<td>Wells Hatchery</td>
<td>PIT/Observation/creel(^a)</td>
</tr>
<tr>
<td>Okanagan steelhead</td>
<td>Okanagan, Similkameen</td>
<td>PIT/Observation/creel(^a,b)</td>
</tr>
<tr>
<td>Twisp spring Chinook NNI</td>
<td>Twisp</td>
<td>CWT</td>
</tr>
<tr>
<td>Chewuch spring Chinook NNI</td>
<td>Chewuch</td>
<td>CWT</td>
</tr>
<tr>
<td>Methow spring Chinook NNI</td>
<td>Methow</td>
<td>CWT</td>
</tr>
<tr>
<td>Wells summer Chinook</td>
<td>Wells Hatchery</td>
<td>CWT</td>
</tr>
</tbody>
</table>

\(^a\) The number of strays will also be estimated during broodstock collection activities or PIT tag detections at Columbia River or tributary dams/detectors, where applicable.

\(^b\) The Okanogan steelhead assessment is performed by the CCT.
Schedule of Activities

Table 13. Schedule for data analysis to determine stray rates of hatchery fish (D = data collection; A = data analysis).

<table>
<thead>
<tr>
<th>Target population</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow steelhead</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Okanogan steelhead</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methow Basin spring Chinook</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wells summer Chinook</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

Objective 6. Determine if hatchery fish were released at the programmed size and number.

Hypotheses:

- $H_{07}^\text{fish}$: Hatchery fish $\text{Size at release} = \text{Programmed Size at release}$
- $H_{a7}^\text{fish}$: Hatchery fish $\text{Size at release} \neq \text{Programmed Size at release}$
- $H_{08}^\text{fish}$: Hatchery fish $\text{Number released} = \text{Programmed Number released}$
- $H_{a8}^\text{fish}$: Hatchery fish $\text{Number released} \neq \text{Programmed Number released}$

General Approach

The HCP outlines the number and size at which fish of each program are to be released. However, analyses in the 5-year report revealed that past length-weight targets are not appropriate. The 5-year report offers new targets based on recent data. New targets should be established, and assessment under this M&E program for 2012 will use the new targets, pending acceptance of the 5-year report by the Hatchery Committee. The programmed size and number of fish for each program will be compared to actual values at release each year. The number of broodstock collected and the population-dynamics assumptions (i.e., sex ratio, fecundity, and survival) in the broodstock collection protocol are important components for consideration. A program’s failure to meet the HCP standards (e.g., over or under program goals) will be evaluated taking into account the number of broodstock and associated population-dynamics assumptions. The size of fish will be compared using a representative sample collected immediately prior to release.

Methodology

The number and size of fish released will be calculated according to methodologies outlined in the M&E Plan (Appendix C). An annual review of size and number of fish from each program will be compared to those values defined in the HCP, or adjusted values agreed to by the Wells HCP Hatchery Committee. If release targets were
achieved within acceptable levels (i.e., 10% +/- of HCP defined values) then no change would be recommended. If release targets are not achieved then causation will be determined and recommendations made based upon the results of the evaluation. A review of the broodstock protocols will occur every five years (or more frequently if necessary) concurrently with an evaluation of the number of fish released from each program.

**Schedule of Activities**

Table 14. Schedule of activities to determine the number and size of fish released (D = data collection; A = data analysis).

<table>
<thead>
<tr>
<th>Target population</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells steelhead</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Wells summer Chinook</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Methow spring Chinook</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

Objective 7: Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of smolts per redd) of supplemented streams when compared to non-supplemented streams.

**Hypotheses:**

- **Ho19:** Slope of Ln(juveniles/redd) vs redds Supplemented population = Slope of Ln(juveniles/redd) vs redds Non-supplemented population
- **Ha19:** Slope of Ln(juveniles/redd) vs redds Supplemented population ≠ Slope of Ln(juveniles/redd) vs redds Non-supplemented population
- **Ho20:** The relationship between proportion of hatchery spawners and juveniles/redd is ≥ 1.
- **Ha20:** The relationship between proportion of hatchery spawners and juveniles/redd is < 1.

**General Approach**

Supplementation should result in an increase in the natural production of the target stock. Given variability in abundance of adult salmonid populations in the Upper Columbia River Basin, monitoring juvenile production (e.g., smolts/redd) should provide a direct assessment of the efficacy of hatchery fish in rebuilding natural populations. Monitoring the freshwater production of both supplemented and non-supplemented populations may provide an early indication of the reproductive success of hatchery fish on the spawning grounds (i.e., no out of basin effects on survival). Conversely, without a smolt monitoring program, changes in smolt production may be masked by out of basin effects. Thus, subsequent recommendations concerning hatchery program modifications may be misdirected.
Smolt monitoring programs are currently ongoing for most treatment streams (Table 15). Coordination with the Agencies operating the various traps is ongoing to ensure similar levels of effort and methodologies are used.

Table 15. Population and location of smolt traps that may be used in examining the influence of hatchery fish on freshwater productivity.

<table>
<thead>
<tr>
<th>Population</th>
<th>Smolt trap</th>
<th>Size</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow Basin spring Chinook</td>
<td>Methow</td>
<td>1 - 8 ft trap; 1 - 5 ft trap</td>
<td>WDFW</td>
</tr>
<tr>
<td>Twisp spring Chinook</td>
<td>Twisp</td>
<td>1 - 5 ft trap</td>
<td>WDFW</td>
</tr>
<tr>
<td>Methow Basin steelhead</td>
<td>Methow</td>
<td>1 - 8 ft trap; 1 - 5 ft trap</td>
<td>WDFW</td>
</tr>
<tr>
<td>Twisp steelhead</td>
<td>Twisp</td>
<td>1 - 5 ft trap</td>
<td>WDFW</td>
</tr>
<tr>
<td>Okanogan steelhead</td>
<td>Okanogan</td>
<td>1 - 8 ft trap; 1 - 5 ft trap</td>
<td>CCT</td>
</tr>
</tbody>
</table>

Comparisons between supplemented and unsupplemented populations require extensive data sets, with potentially high annual variability that may require years before the efficacy of the program can be determined. Furthermore, the Wells steelhead program began decades before the HCP was signed and pretreatment data may not be available. Similarly, large releases of spring Chinook occurred in the Methow Basin for decades before the HCP program began.

**Methodology**

Procedures for this objective are outlined in Appendix E of the M&E Plan. Redd count activities required for this Objective will be accomplished under Objective 2. Juvenile monitoring requires an extensive trapping period (Table 16) over many successive generations due to the diverse life-history of spring Chinook (subyearling and yearling emigrants) and summer steelhead (multiple age-class smolts). Random samples of scales must be collected for all stocks with multiple age-class smolts in order to calculate the number of smolts produced from each brood-year. Whenever possible, direct measurements of the proportion of hatchery fish on the spawning grounds (pHOS) will be conducted (i.e., Twisp Weir). Otherwise, the proportion of hatchery-origin fish on the spawning grounds will be estimated where possible, as will the Proportionate Natural Influence (PNI).

Current estimates of egg-to-smolt survival for Methow spring Chinook are much lower than expected. Based on scale analysis of returning Chinook adults, we assumed that all yearling emigrants at the Methow smolt trap were spring Chinook and subyearling emigrants were summer Chinook. Results of DNA sampling at the Methow River trap during the fall of 2006 and 2007 indicated that the majority of subyearling Chinook captured were spring Chinook. Because of this, fall trapping and DNA sampling will be conducted at the Methow smolt trap to estimate total spring Chinook emigrants.
The low abundance of steelhead and yearling Chinook captured at smolt traps in the Methow Basin limits the sample size to conduct migration timing comparisons and life-stage survival estimates (e.g., PIT tag recaptures). The installation of PIT tag antenna arrays in the lower Twisp and Methow rivers will provide additional opportunities to assess migration behavior and survival, and detection rates should increase with additional PIT-tagging of hatchery and wild fish conducted under Objective 4 and Objective 1, respectively.

### Schedule of Activities

Table 16. Schedule of activities for smolt monitoring programs in the Methow Basin (D = data collection; A = data analysis).

<table>
<thead>
<tr>
<th>Target population</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow Basin steelhead</td>
<td>A</td>
<td>D/A</td>
<td>D/A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D/A</td>
</tr>
<tr>
<td>Twisp steelhead</td>
<td>A</td>
<td>D/A</td>
<td>D/A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D/A</td>
</tr>
<tr>
<td>Methow Basin spring Chinook</td>
<td>A</td>
<td>D/A</td>
<td>D/A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D/A</td>
</tr>
<tr>
<td>Twisp spring Chinook</td>
<td>A</td>
<td>D/A</td>
<td>D/A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D/A</td>
</tr>
<tr>
<td>Methow summer Chinook</td>
<td>A</td>
<td>D/A</td>
<td>D/A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D/A</td>
</tr>
</tbody>
</table>

Objective 8: Determine if harvest opportunities have been provided using hatchery returning adults where appropriate (e.g., Wells Chinook salmon).

Hypotheses:

- $H_0^{21}$: Harvest rate $\leq$ Maximum level to meet program goals
- $H_a^{21}$: Harvest rate $>$ Maximum level to meet program goals
- $H_0^{22}$: Escapement $\geq$ Maximum level to meet supplementation goals
- $H_a^{22}$: Escapement $<$ Maximum level to meet supplementation goals

### General Approach

In years when the expected returns of hatchery adults are above the levels required to meet program goals (i.e., broodstock, natural escapement), surplus fish may be available for harvest. Harvest of returning adults is the goal of some programs (e.g., Wells summer Chinook) and an ancillary benefit of other programs (e.g., Methow/Okanogan steelhead). Contribution to fisheries, whether incidental or directed, will be monitored using CWT recoveries on a brood-year basis. Target harvest rates have not been outlined in the M&E Plan. Hence, a qualitative assessment of the contribution rates of hatchery fish to fisheries versus broodstock or spawning grounds is required to determine if the objective has been met.
One approach, based on the goal of the hatchery program, is to compare CWT recoveries by recovery location (i.e., broodstock, fisheries, or spawning grounds). For example, a majority of the CWT recoveries for harvest augmentation programs should occur in fisheries. Conversely, supplementation programs should have a majority of the CWT recoveries occur on the spawning grounds.

**Methodology**

Robust statistically valid creel survey programs will be conducted for all sport fisheries in the Upper Columbia River to estimate harvest of hatchery fish from hatchery programs funded by Douglas County PUD (M&E Plan Appendix D). Creel survey programs will be designed and implemented by WDFW Fish Management staff. Creel surveys in the Upper Columbia River are also an important component in calculating the HRR (Objective 4) because most CWT recoveries occur within the Upper Columbia River, the exception being summer Chinook. Significant time lags in reporting CWT recovery data to the Regional Mark Information System (RMIS) database requires a continual requerying of recovery data until the number of estimated fish does not change. The number of fish and proportion by brood year for CWT recoveries will be summarized in several categories (Table 17).

Table 17. Categories for CWT recoveries of hatchery fish released from Douglas County PUD funded programs.

<table>
<thead>
<tr>
<th>Category</th>
<th>Estimated number of fish (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broodstock</td>
<td>Total</td>
</tr>
<tr>
<td>Spawning ground</td>
<td>Total</td>
</tr>
<tr>
<td>Fisheries</td>
<td>Total</td>
</tr>
<tr>
<td>Commercial</td>
<td>Ocean</td>
</tr>
<tr>
<td>Sport</td>
<td>Ocean</td>
</tr>
</tbody>
</table>

**Schedule of Activities**

Table 18. Schedule of activities to determine harvest rates of hatchery fish (D = data collection; A = data analysis).

<table>
<thead>
<tr>
<th>Target population</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methow/Okanogan steelhead</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Wells summer Chinook</td>
<td></td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methow basin spring Chinook</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DELIVERABLES

**Annual Reports:** A draft annual report will be provided to Douglas PUD by 1 July, 2012. A final report will be provided to the HCP HC within 30 days of receiving comments on the draft report. The annual report will summarize all field activities conducted during the contract period. The format of the report will be similar to the 2010 annual report that has been provided to Douglas PUD, with each task reported in a separate chapter. Primary indicators and the data used in calculations during each task will also be presented in each chapter. Secondary and tertiary indicators will be reported if needed to calculate the primary indicator.

**Chapter 1. Hatchery Brood Report**
- **Broodstock**
  - Number collected
  - Age composition
  - Size at maturity
  - Report on Chewuch spring Chinook broodstock collection efforts
- **Juvenile**
  - Number released
  - Size at release
- **Hatchery replacement rates**

**Chapter 2. Harvest**
- **Hatchery fish**
  - Number
  - Location
  - Stray rates
- **Wild fish**
  - Number
  - Location

**Chapter 3. Smolt Monitoring**
- **Smolt production**
  - Number of smolts (captured and total estimate)
  - Smolts/redd
  - Size at emigration
  - Age at emigration
- **Survival**
  - Egg to emigrant survival
  - Number of fish PIT-tagged
  - Smolt-to-smolt survival
- **Remote PIT-tagging**
  - Number tagged
Chapter 4. Steelhead Spawning Ground Surveys

a. Migration timing
b. Spawn timing
c. Redd distribution
   - Number of redds
   - Spawning escapement
   - Spawner composition
   - pHOS and PNI estimates
   - Number of NOR
   - NRR
   - Stray rates

Chapter 5. Chinook Spawning Ground Surveys

a. Migration timing
b. Spawn timing
c. Redd distribution
   - Number of redds
   - Spawning escapement
   - Spawner composition
   - pHOS and PNI estimates
   - Number of NOR
   - NRR
   - Stray rates

Recommendations: Recommendations to modify the M&E Plan or reporting will occur on an annual basis and again within the five-year summaries. Initially, changes to protocols or methodologies may be necessary to ensure the data required in the M&E Plan is collected. Changes to the M&E Plans’ implementation or hypotheses will be included in the five-year summary report. Recommendations will be consistent with the hatchery program goals and will be included in a separate section of the summary report.

Presentations: A formal presentation (i.e., PowerPoint format) of the M&E Plan results will be provided to Douglas PUD or the HCP HC at their convenience. Presentations will include the status of all hatchery programs in meeting their objectives, potential problems and recommendations. Similar presentations of annual results from field activities can be requested and provided if warranted.

COORDINATION BETWEEN DOUGLAS PUD AND HATCHERY STAFF

The WDFW Supplementation Research Team (a.k.a. Methow Field Office) has been directly involved in the evaluation, development, and implementation of the hatchery programs since 1992. Currently, the WDFW is contracted by Douglas PUD not only to operate its hatcheries, but also to implement the Evaluation Plan developed when the Methow Hatchery program came online.
Coordination with hatchery staff has been a continual process. Hatchery staff conducts routine sampling at the hatcheries and data is provided to us for inclusion in monthly reports. However, special meetings with the hatchery staff are typically conducted prior to significant events (i.e., broodstock collection, spawning, release of juveniles) to ensure proper methodologies are used and critical data is collected. Evaluation staff is present at all significant events and collect data needed for evaluation purposes.

Additional coordination between evaluation staff, hatchery staff, and the WDFW ESA Permitting biologist is often required to ensure that conditions of ESA Section 10 permits are not violated. The ESA permitting biologist is co-located with evaluation staff, which allows for efficient and effective communication on a daily basis in order to ensure compliance with existing permits. Currently, all ESA reporting related to the hatchery programs is the responsibility of the WDFW Permitting Biologist (0.5 FTE). Given the limited resources dedicated to ESA Permit reporting and the extensive workload required to meet reporting requirements, this relationship is critical to ensuring hatchery programs operate within the conditions of the permit.

Monthly reports have served as a primary mode of coordination and are used to keep Douglas PUD as well as HCP Committee members and co-managers informed on all hatchery and evaluation related activities. Unless otherwise requested by Douglas PUD, the role of monthly reports will remain the same. Upon request, additional information can be included in the monthly reports.

References


APPENDIX D

ANNUAL BROODSTOCK COLLECTION PROTOCOLS
To: Craig Busack, NMFS  
From: Mike Tonseth, WDFW  
Subject: DRAFT 2013 UPPER COLUMBIA RIVER SALMON AND STEELHEAD BROODSTOCK OBJECTIVES AND SITE-BASED BROODSTOCK COLLECTION PROTOCOLS

The attached protocol was developed for hatchery programs rearing spring Chinook salmon, summer Chinook salmon and summer steelhead associated with the mid-Columbia HCPs, spring Chinook salmon and steelhead programs associated with the 2008 Biological Opinion for the Priest Rapids Hydroelectric Project (FERC No. 2114) and fall Chinook consistent with Grant County Public Utility District and Federal mitigation obligations associated with Priest Rapids and John Day dams (ACOE funded), respectively. These programs are funded by Chelan, Douglas, and Grant County Public Utility Districts (PUDs) and are operated by the Washington Department of Fish and Wildlife (WDFW).

This protocol is intended to be a guide for 2013 collection of salmon and steelhead broodstocks in the Methow, Okanogan, Wenatchee, and Columbia River basins. It is consistent with previously defined program objectives such as program operational intent (i.e., conservation and/or harvest augmentation), mitigation production levels (HCPs, Priest Rapids Dam 2008 Biological Opinion), changes to programs as approved by the HCP-HC, and to comply with ESA permit provisions.

Notable in this years protocols are:

- Continuing for 2013, no age-3 males will be incorporated into spring or summer Chinook programs.

- Implementation of the draft Production Management Plan (Appendix B), for all programs where possible, to ensure mitigation production levels are met and that the permitted production ceiling is not exceeded at release.

- Chelan PUD’s 2013 Methow spring Chinook Obligation of 60,516 smolts will be met through eyed egg transfers to Eastbank FH from adults collected and spawned at Winthrop National Fish Hatchery.
• Utilization of genetic sampling/assessment to differentiate Twisp River and Methow Basin natural-origin spring Chinook adults collected at Wells Dam, and CWT interrogation during spawning of hatchery spring Chinook collected at the Twisp Weir, Methow FH and Winthrop NFH to differentiate Twisp and Methow Composite hatchery fish for discrete management of Twisp and Methow Composite production components.

• Collection of only hatchery adult steelhead at Wells Dam/hatchery for MFH safety net, Winthrop conservation, and Wells Hatchery Okanogan and mainstem Columbia programs.

• Implementation of Grant PUD’s Nason Creek spring Chinook program beginning with the 2013 brood contingent upon permitting.

• Targeted collection of natural origin spring Chinook at Tumwater Dam for both the Nason Creek and Chiwawa conservation programs.

• Targeted collection of 100% of the Wenatchee summer Chinook and Wenatchee hatchery origin steelhead broodstock at Dryden Dam to reduce the number of activities that may contribute to delays in fish passage at Tumwater Dam (some adult collections at Tumwater may be necessary if sufficient adults cannot be acquired at Dryden Dam).

• Targeted collection of 100% of the natural origin steelhead broodstock at Tumwater Dam.

• Collection of summer Chinook broodstock from the Eastbank outfall, sufficient to meet a 576K yearling juvenile Chelan Falls program. The Wells volunteer channel will be the fallback location if insufficient females are collected in the outfall.

• Collection of 24-natural origin steelhead at the Twisp Weir in the spring of 2014. Adults will be transferred to Methow Hatchery for spawning and biosecure, isolated incubation through the eyed-egg stage after which they will be moved to Wells FH for the remainder of rearing.

• Collection of surplus hatchery origin steelhead from the Twisp Weir (up to 25% of the required broodstock) to produce the 100K Methow safety-net on-station-released smolts (up to 13 adults). The remainder of the broodstock (37) will be WNFH returns collected at WNFH and/or Methow Hatchery and surplus to the WNFH program needs. Collection of Wells stock may be used if WNFH and Twisp returns are insufficient. The collection of adults will occur in spring of 2014.

• With the CCT summer Chinook program ramping up with the 2013 brood year, only collections of summer Chinook for the Grant PUD’s obligation in the Methow (Carlton program) are scheduled to occur at Wells Dam. Summer Chinook collections at Wells Dam to support the CJH program may occur if CCT broodstock collection efforts fail to achieve broodstock collection objectives.
• The collection from the Wells Hatchery volunteer channel of Wells summer Chinook to support the USFWS, Entiat NFH summer Chinook programs (requires agreement of the HCP Hatchery Committee [HC]).

• Collection from the Wells Hatchery volunteer channel of Wells summer Chinook to support the YN, Yakima River summer Chinook program.

These protocols may be adjusted in-season, based on actual run monitoring at mainstem dams and/or other sampling locations. Additional adaptive management actions as they relate to broodstock objectives may be implemented as determined by the HCP-HC or PRCC-HSC and within the boundaries of applicable permits.

Above Wells Dam

Spring Chinook

Inclusion of natural-origin fish in the broodstock will be a priority, with natural-origin fish specifically being targeted. Collections of natural-origin fish will not exceed 33% of the Methow Composite (i.e., non-Twisp) and Twisp natural-origin run escapement consistent with take provisions in Section 10 (a)(1)(A) Permit 1196.

To facilitate BKD management, comply with ESA Section 10 permit take provisions, and to meet programmed production, hatchery-origin spring Chinook will be collected in numbers excess to program production requirements. Based on historical Methow FH spring Chinook ELISA levels above 0.12, the hatchery origin spring Chinook broodstock collection will include hatchery origin spring Chinook in excess to broodstock requirements by approximately 18.2% (based upon the most recent 5-year mean ELISA results for the program). For purposes of BKD management and to comply with maximum production levels and other take provisions specified in ESA Section 10 permit 1196, culling will include the destruction of eggs from hatchery-origin females with ELISA levels greater than 0.12 and/or that number of hatchery origin eggs required to maintain production at 163,249 yearling smolts. Culling of eggs from natural-origin females will not occur unless their ELISA levels are determined by WDFW Fish Health to be a substantial risk to the program. Progeny of natural-origin females, with ELISA levels greater than 0.12, will be differentially tagged for evaluation purposes. Annual monitoring and evaluation of the prevalence and level of BKD and the efficacy of culling in returning hatchery- and natural-origin spring Chinook will continue and will be reported in the annual monitoring and evaluation report for this program.

Recent WDFW genetic assessment of natural-origin Methow spring Chinook (Small et al. 2007) indicated that Twisp natural-origin spring Chinook can be distinguished, via genetic analysis, from non-Twisp spring Chinook with a high degree of certainty. The Wells HCP Hatchery Committee accepted that Twisp-origin fish could be genetically assigned with sufficient confidence that natural origin collections can occur at Wells Dam. Scale samples and non-lethal tissue samples (fin clips) for genetic analysis will be obtained from adipose-present, non-CWT,
non-ventral-clipped spring Chinook (suspected natural-origin spring Chinook) collected at Wells Dam, and origins assigned based on that analysis. Natural-origin fish retained for broodstock will be PIT tagged (pelvic girdle) for cross-referencing tissue samples/genetic analyses. Tissue samples will be preserved and sent to the WDFW genetics lab in Olympia Washington for genetic/stock analysis. The spring Chinook from Wells will be retained at Methow Hatchery and spawned for each program depending on results of DNA analysis.

The number of natural-origin Twisp and Methow Composite (non-Twisp) spring Chinook retained will be dependent upon the number of natural-origin adults returning and the collection objective limiting extraction to no greater than 33% of the natural-origin spring Chinook return to the Methow Basin. Natural origin fish not assigning to the Twisp or Methow Composite (combined, these make up the entire Methow Basin spring Chinook population) will be released back into the Columbia River (Natural origin adults with some level of Carson ancestry may be retained for broodstock provided they are no less than grandparents). Based on the broodstock-collection schedule at Wells Dam (3-day/week, 16 hours/day), extraction of natural-origin spring Chinook is expected to be approximately 33% or less.

Weekly estimates of the passage of Wells Dam by natural-origin spring Chinook will be provided through stock-assessment and broodstock-collection activities. This information will facilitate in-season adjustments to collection composition so that extraction of natural-origin spring Chinook remains less than 33%. Trapping at the Winthrop NFH will be included if needed because of broodstock shortfalls.

Pre-season run-escapement of Methow-origin spring Chinook above Wells Dam during 2013 is estimated at 1,808 spring Chinook, including 1,589 hatchery and 219 natural origin spring Chinook (Table 1 and Table 2). In-season estimates of natural-origin spring Chinook will be adjusted proportional to the estimated returns to Wells Dam at weekly intervals and may result in adjustments to the broodstock collection targets presented in this document.

The following broodstock collection protocol was developed based on the re-calculated program production levels (163,249 smolts – Chelan PUD spring Chinook production of 60,516 smolts will be met through Winthrop NFH collections (likely MetComp II’s) and result in transfer of eyed eggs to EB FH per HCP-HC agreements for 2013), BKD management strategies, projected return for BY 2013 Methow Basin spring Chinook at Wells Dam (Table 1 and Table 2), and assumptions listed in Table 3.

The 2013 Methow spring Chinook broodstock collection will target up to 108 adult spring Chinook (24 Twisp, 84 Methow). Based on the pre-season run forecast, Twisp fish are expected to represent 9% of the adipose present, CWT tagged hatchery adults and 10.5% of the natural origin spring Chinook passing above Wells Dam (Tables 1 and 2). Based on this proportional contribution and a collection objective to limit extraction to no greater than 33% of the natural-origin spawning escapement to the Twisp, the 2013 Twisp origin broodstock collection will total 24 fish (7 wild and 17 hatchery origin), representing 100% of the broodstock necessary to meet Twisp program production of 30,000 smolts. Methow Composite fish are expected to represent 42% of the adipose present CWT tagged hatchery adults and 89.5% of the natural origin spring Chinook passing above Wells Dam (Tables 1 and 2). Based on this proportional contribution
and a collection objective to limit extraction to no greater than 33% of the natural-origin recruits, the 2013 Methow broodstock collection will total 88 spring Chinook (64 wild and 24 Hatchery). The broodstock collected for the Methow program represents 100% of the broodstock necessary to meet Methow program production of 133,249 smolts. The Twisp River releases will be limited to releasing progeny of broodstock identified as wild Twisp and or known Twisp hatchery origin fish, per ESA Permit 1196. The Methow FH releases will include progeny of broodstock identified as wild non-Twisp origin and known Methow Composite hatchery origin fish. Age-3 males (“jacks”) will not be collected for broodstock.

Table 1. Brood year 2008-2010 age class-at-return projection for wild spring Chinook above Wells Dam, 2013.

<table>
<thead>
<tr>
<th>Brood year</th>
<th>Smolt Estimate</th>
<th>Twisp Basin</th>
<th>Methow Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Twisp&lt;sup&gt;1/&lt;/sup&gt;</td>
<td>Methow Basin&lt;sup&gt;2/&lt;/sup&gt;</td>
<td>Age-3</td>
</tr>
<tr>
<td>2008</td>
<td>11,932</td>
<td>56,337</td>
<td>7</td>
</tr>
<tr>
<td>2009</td>
<td>5,124</td>
<td>31,212</td>
<td>7</td>
</tr>
<tr>
<td>2010</td>
<td>8,927</td>
<td>50,165</td>
<td>2</td>
</tr>
</tbody>
</table>

Estimated 2013 Return

2<sup>1/</sup>-Smolt estimate is based on sub-yearling and yearling emigration (Charlie Snow, personal communication).

2<sup>2/</sup>-Estimated Methow Basin smolt emigration based on Twisp Basin smolt emigration, proportional redd deposition in the Twisp River and Twisp Basin smolt production estimate.

3<sup>3/</sup>- Mean Chiwawa NOR spring Chinook SAR to the Wenatchee Basin (BY 1998-2003; WDFW unpublished data).

Table 2. Brood year 2008-2010 age class and origin run escapement projection for UCR spring Chinook at Wells Dam, 2013.

<table>
<thead>
<tr>
<th>Stock</th>
<th>Age-3</th>
<th>Age-4</th>
<th>Age-5</th>
<th>Total</th>
<th>Methow Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age-3</td>
<td>Age-4</td>
<td>Age-5</td>
<td>Total</td>
<td>Age-3</td>
</tr>
<tr>
<td>MetComp</td>
<td>138</td>
<td>468</td>
<td>67</td>
<td>673</td>
<td>9</td>
</tr>
<tr>
<td>%Total</td>
<td>42%</td>
<td></td>
<td></td>
<td></td>
<td>89%</td>
</tr>
<tr>
<td>Twisp</td>
<td>33</td>
<td>98</td>
<td>6</td>
<td>137</td>
<td>2</td>
</tr>
<tr>
<td>%Total</td>
<td>9%</td>
<td></td>
<td></td>
<td></td>
<td>11%</td>
</tr>
<tr>
<td>Winthrop</td>
<td>98</td>
<td>626</td>
<td>55</td>
<td>779</td>
<td>98</td>
</tr>
<tr>
<td>(MetComp) %Total</td>
<td>49%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>269</td>
<td>1,192</td>
<td>128</td>
<td>1,589</td>
<td>11</td>
</tr>
</tbody>
</table>
Table 3. Assumptions and calculations to determine the number of broodstock needed for BY 2013 production of 163,249 smolts.

<table>
<thead>
<tr>
<th>Program Assumptions</th>
<th>Twisp standard</th>
<th>Twisp program</th>
<th>Methow standard</th>
<th>Methow program</th>
<th>Total program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smolt Release</td>
<td>30,000</td>
<td>133,249</td>
<td>163,249</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilization-to-release survival</td>
<td>86.5%&lt;sup&gt;1&lt;/sup&gt;</td>
<td>84.8%&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total egg take target</td>
<td>34,682</td>
<td>157,133</td>
<td>191,815</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg take (production)</td>
<td>45,455</td>
<td>163,423</td>
<td>208,878</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cull allowance&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fecundity&lt;sup&gt;3&lt;/sup&gt;</td>
<td>3,626H/3,715W</td>
<td>3,719H/4,027W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female Target</td>
<td>1:1</td>
<td>1:1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female to male ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broodstock target</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-spawn survival</td>
<td>91.8%</td>
<td>98%</td>
<td>98.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total broodstock collection</td>
<td>7W</td>
<td>64W</td>
<td>17H</td>
<td>24H</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup>- Median values.

<sup>2</sup>- Hatchery origin MetComp. component only, and is based on the projected natural origin collection and assumption that all Twisp (hatchery and wild) and wild MetComp. fish will be retained for production.

<sup>3</sup>- Based on historical age-4 fecundities and expected 2012 return age structure (Table 1).

Trapping at Wells Dam will occur at the East and West ladder traps beginning on 01 May, or at such time as the first spring Chinook are observed passing Wells Dam, and continue through 21 June 2013. The trapping schedule will consist of 3-day/week (Monday-Wednesday), up to 16-hours/day. Two of the three trapping days will be concurrent with the stock assessment sampling activities authorized through the 2013 Douglas PUD Hatchery M&E Implementation Plan. Natural origin spring Chinook will be retained from the run, consistent with spring Chinook run timing at Wells Dam (weekly collection quota). Collection goals will be developed by Wells M&E staff to identify the most appropriate special and temporal approach to achieving the overall brood target. All natural origin spring Chinook collected at Wells Dam for broodstock will be held at the Methow FH.

To meet Methow FH broodstock collection for hatchery origin Methow Composite and Twisp River stocks, adipose-present coded-wire tagged hatchery fish will be collected at Methow FH, Winthrop NFH and the Twisp Weir beginning 01 May or at such time as spring Chinook are observed passing Wells Dam and continuing through 23 August 2013. Natural origin spring Chinook will be retained at the Twisp Weir as necessary to bolster the Twisp program production so long as the aggregate collection at Wells Dam and Twisp River weir does not
exceed 33% of the estimated Twisp River natural origin spawners to maximize pNOS in the Twisp. All hatchery and natural origin fish collected at Methow FH, Twisp Weir and Winthrop NFH for broodstock will be held at the Methow FH.

Steelhead

Steelhead programs located upstream of Wells Dam and at Wells Hatchery are presented in Table 4.

Table 4. 2014 brood year Steelhead Programs at Wells Hatchery and Upstream of Wells Dam

<table>
<thead>
<tr>
<th>Program</th>
<th>Hatchery</th>
<th>Owner</th>
<th>Release Location</th>
<th>Release Target</th>
<th>Broodstock Collection Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twisp Conservation</td>
<td>Methow Hatchery</td>
<td>Douglas PUD</td>
<td>Twisp Acclimation Pond</td>
<td>48,000</td>
<td>Twisp WxW</td>
</tr>
<tr>
<td></td>
<td>(incubation);</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wells Hatchery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(rearing)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methow Safety-Net</td>
<td>Wells Hatchery</td>
<td>Douglas PUD</td>
<td>Methow Hatchery</td>
<td>100,000</td>
<td></td>
</tr>
<tr>
<td>Mainstem Columbia Safety-Net</td>
<td>Wells Hatchery</td>
<td>Douglas PUD</td>
<td>Wells Hatchery</td>
<td>160,000</td>
<td></td>
</tr>
<tr>
<td>WNFH Conservation Program</td>
<td>WNFH</td>
<td>USFWS</td>
<td>WNFH</td>
<td>100,000</td>
<td></td>
</tr>
<tr>
<td>Omak Creek</td>
<td>Wells Hatchery</td>
<td>Grant PUD</td>
<td>Omak Creek</td>
<td>Up to 20,000¹</td>
<td></td>
</tr>
<tr>
<td>Okanogan</td>
<td>Wells Hatchery</td>
<td>Grant PUD</td>
<td>Okanogan Basin</td>
<td>Up to 100,000¹</td>
<td>Wells Stock collected at Wells Dam/Hatchery</td>
</tr>
</tbody>
</table>

¹ The Grant PUD programs will total 100,000, with Omak Creek taking precedence. Until CCT has a new Section 10 permit authorizing more than 20,000 smolts (16 broodstock) for the endemic program, production and broodstock collections will remain consistent with the previous permit.

Steelhead mitigation programs above Wells Dam (including the USFWS steelhead program at Winthrop NFH) utilize adult broodstock collections at Wells Dam, Twisp Weir, Methow Hatchery volunteer trap, and WNFH volunteer trap (Table 5) and incubation/rearing at Wells Fish Hatchery (FH) and incubation at Methow Hatchery (Twisp program). The Wells Steelhead Program has provided eggs for UCR steelhead reared at Ringold FH, not as a mitigation requirement, but rather an opportunity to reduce the prevalence of early spawn hatchery steelhead in the mitigation component above Wells Dam. However, the Methow steelhead program is shifting to locally collected Twisp wild broodstock (Twisp conservation program), and hatchery origin broodstock representative of the Twisp and WNFH conservation programs (Methow safety-net program). Therefore, surplus broodstock will not be collected for the
Methow steelhead programs to address the spawn-timing issue of the Wells stock. The Wells Hatchery Columbia River releases will use returns to the Methow Hatchery volunteer trap to the extent possible, and will be augmented with Wells stock as required to fulfill the program. However, the local collections of broodstock in the Methow Basin will occur in the spring, 2014. To ensure the safety-net programs have broodstock, some broodstock will be collected at Wells Dam in the autumn, 2013, and held at Wells Hatchery. These autumn-collected Wells stock fish will be considered surplus to the spring-collected Methow and Okanogan broodstock, and eggs from these surplus broodstock may be transferred to Ringold Hatchery. In addition, Wells Hatchery may be used for adult management and steelhead removed for adult management may be retained for the Ringold program (Table 5).

Table 5. Broodstock collection locations, number, and origin by program.

<table>
<thead>
<tr>
<th>Program</th>
<th>Wells Dam or Hatchery</th>
<th>Twisp Weir</th>
<th>WNFH</th>
<th>Methow Hatchery</th>
<th>Omak Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H W</td>
<td>H W</td>
<td>H W</td>
<td>H W</td>
<td>H W</td>
</tr>
<tr>
<td>Twisp Conservation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methow Safety-Net</td>
<td>as needed</td>
<td>13</td>
<td>0</td>
<td>Up to 52 (backup)</td>
<td>0</td>
</tr>
<tr>
<td>Mainstem Columbia Safety-Net</td>
<td>82 (backup)</td>
<td>0</td>
<td></td>
<td>82</td>
<td>0</td>
</tr>
<tr>
<td>WNFH Conservation Program</td>
<td>25</td>
<td></td>
<td></td>
<td>26¹</td>
<td></td>
</tr>
<tr>
<td>Omak Creek</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Up to 16²</td>
</tr>
<tr>
<td>Okanogan</td>
<td>Up to 42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ringold³</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td>0</td>
<td>13</td>
<td>24</td>
<td>52</td>
</tr>
</tbody>
</table>

¹ Wild origin fish for WNFH program will be collected through USFWS hook and line angling efforts in the Methow in the spring of 2014.
² Wild origin preferred, but hatchery origin broodstock will also be collected to meet target.
³ Broodstock derived from adult management at Wells Hatchery and surplus brood collected as backup for Methow and Okanogan programs.

The following broodstock collection protocol was developed based on mitigation program production objectives (Table 6), program assumptions (Table 7), and the probability that sufficient adult steelhead will return in 2013/2014 to meet production objectives absent a preseason forecast at the present time.

Trapping at Wells Dam will selectively retain up to 149 hatchery origin steelhead (East and West ladder collection). Ringold FH production will be based on the availability and comprised of surplus eggs/fish resultant from managing any production overruns in DC and GC PUD production. No adults for the Ringold program will be specifically targeted at Wells. In the spring of 2014, 24 wild steelhead will be targeted at the Twisp Weir and transferred to the Methow Hatchery for spawning and incubation to the eyed-egg stage after which they will be moved to Wells Hatchery for the balance of rearing. In addition, up to 13 surplus hatchery-origin steelhead (to meet the 100K Methow Safety-Net release) will be targeted at the Twisp Weir and/or Methow Hatchery and either spawned/incubated at Methow FH or moved to Wells Hatchery for spawning. Surplus WNFH hatchery returns will be used to augment the
Twisp/Methow hatchery-origin collection if needed. Should there be inadequate surplus steelhead from these two sources, steelhead captured at the Methow Hatchery volunteer trap will be used to fulfill the program. Wells stock held at the Wells Hatchery will be used as a final option. Approximately, 16 adult steelhead will be targeted in Omak Creek for a 20K endemic program operated by the CCT and funded by GCPUD as part of their 100K UCR steelhead mitigation obligation. Overall collection for the programs will be 255 fish (a combination of program specific and back-up adults) and limited to no more than 33% of the entire run or 33% of the natural origin return (NOR composition in the broodstock, is estimated at 17%). Hatchery and natural origin collections will be consistent with run-timing of hatchery and natural origin steelhead at Wells Dam. Ladder trapping at Wells Dam will begin on 01 August and terminate by 31 October, three days per week, up to 16 hours per day, if required to meet broodstock objectives. Trapping will be concurrent with summer Chinook broodstocking efforts through 15 September on the west ladder. If insufficient steelhead adults are encountered on the west ladder, the east ladder trap may be considered. Adult return composition including number, origin, age structure, and sex ratio will be assessed in-season at Priest Rapids and Wells dams. Broodstock collection adjustments may be made based on in-season monitoring and evaluation. If collection of adults from the east ladder trap is necessary, access will be coordinated with staff at Wells Dam due to the rotor rewind project.

Table 6. Adult steelhead collection objectives for programs supported through 2013 return year adult steelhead broodstock collected at Wells Dam, Twisp Weir, WNFH, and Omak Creek (CCT endemic program).

<table>
<thead>
<tr>
<th>Program</th>
<th># Smolts</th>
<th># Green eggs</th>
<th>% Wild</th>
<th># Wild</th>
<th># Hatchery</th>
<th>Total Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCPUD</td>
<td>160,000</td>
<td>226,629</td>
<td></td>
<td></td>
<td>82</td>
<td>82</td>
</tr>
<tr>
<td>DCPUD</td>
<td>100,000</td>
<td>141,643</td>
<td></td>
<td></td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>DCPUD Twisp</td>
<td>48,000</td>
<td>67,989</td>
<td>100%</td>
<td>24</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>GCPUD</td>
<td>80,000</td>
<td>113,315</td>
<td></td>
<td></td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>GCPUD Omak</td>
<td>20,000</td>
<td>40,000</td>
<td>100%</td>
<td>16</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>USFWS</td>
<td>50,000</td>
<td>70,821</td>
<td></td>
<td></td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Sub-total</td>
<td>458,000</td>
<td>660,397</td>
<td>16%</td>
<td>40</td>
<td>202</td>
<td>242</td>
</tr>
</tbody>
</table>

| Ringold              | 180,000  | 285,714      |        |        |            |              |
| Sub-total            | 180,000  | 285,714      |        |        |            |              |

| Grand Total          | 638,000  | 946,111      | 16%    | 40     | 215        | 255          |

1/ Mainstem Columbia releases at Wells Dam. Target HxH parental adults as the hatchery component.
2/ Methow hatchery release of HxH fish produced from either adults returning from the Winthrop conservation program, adults trapped at MFH, and/or surplus hatchery adults from the Twisp weir.
3/ Okanogan Basin releases as part of GCPUD’s 100K summer steelhead obligation. Broodstock need is dependent on the Omak collection to achieve 100,000 smolts total.
4/ Broodstock targeted is 16 total (8 male/8 female) of mixed origin composition based upon what is trapped.
5/ Eggs/juveniles will be provided to the Ringold program consistent with management of program surpluses up to 180,000 smolts. Adults for the Ringold program will not be specifically targeted at Wells Dam/Hatchery in 2013.
6/ Based on steelhead production consistent with Mid-Columbia HCP’s, GCPUD BiOp and Section 10 permit 1395.
Table 7. Program assumptions used to determine the number of adults required to meet steelhead production objectives for programs above Wells Dam.

<table>
<thead>
<tr>
<th>Program assumptions</th>
<th>Hatchery</th>
<th>Wild</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-spawn survival</td>
<td>95.4%</td>
<td>97.6%</td>
</tr>
<tr>
<td>Female : Male ratio</td>
<td>1.0:1.0</td>
<td>1.0:1.0</td>
</tr>
<tr>
<td>Fecundity</td>
<td>5,822</td>
<td>5,800</td>
</tr>
<tr>
<td>Fertilization-to-yearling release</td>
<td>70.6%</td>
<td>70.6%</td>
</tr>
</tbody>
</table>

**Summer/fall Chinook**

The summer/fall Chinook mitigation program in the Methow River utilizes adult broodstock collections at Wells Dam and incubation/rearing at Eastbank Fish Hatchery. The total production level target is 200,000 summer/fall Chinook smolts for acclimation at Carlton Pond.

The TAC 2012 Columbia River UCR summer Chinook return projection to the Columbia River (Appendix A) and BY 2008, 2009 and 2010 spawn escapement to tributaries above Wells Dam indicate sufficient summer Chinook will return past Wells Dam to achieve full broodstock collection for supplementation programs above Wells Dam. The following broodstock collection protocol was developed based on initial run expectations of summer Chinook to the Columbia River, program objectives and program assumptions (Table 8).

For 2013, WDFW will retain up to 102 natural-origin summer/fall Chinook at Wells Dam east and/or west ladders, including 51 females for the Methow summer Chinook program. Collection will be proportional to return timing between 01 July and 15 September. Trapping may occur up to 3-days/week, 16 hours/day. Age-3 males (“jacks”) will not be collected for broodstock.

Additionally, in 2013 broodstock collection for Okanogan based summer Chinook programs will fall under the responsibility of the Colville Tribes as part of their overall summer Chinook program. Broodstock collection will be prioritized through purse seine operations, ladder returns to the Chief Joe Hatchery, tangle netting and the Okanogan weir. Should use of Wells Dams be needed to meet any shortfalls in broodstock, the CCT will notify the HCP-HC and coordinate with Douglas PUD, Grant PUD, and WDFW to facilitate additional effort. Summer Chinook broodstock collection efforts at Wells Dam, should they be required to meet CJH program objectives will be conducted concurrent with broodstock collection efforts for the Methow summer Chinook program and or steelhead collection efforts for steelhead programs above Wells Dam.

To better assure achieving the appropriate females for program production, the collection will utilize ultrasonography to determine the sex of each fish retained for broodstock. If the probability of achieving the broodstock goal is reduced based on passage at the west ladder or actual natural-origin escapement levels, broodstock collections may be expanded to the east ladder trap and/or origin composition will be adjusted to meet the broodstock collection objective. If collection of adults from the east ladder trap is necessary, access will be coordinated with staff at Wells Dam due to the rotor rewind project.
Table 8. Assumptions and calculations to determine the number of broodstock needed for 2013 brood summer/fall Chinook production goals in the Methow River basin and CCT summer programs as needed based upon success of planned broodstocking methods.

<table>
<thead>
<tr>
<th>Program Assumptions</th>
<th>Metrics</th>
<th>Carlton Pond</th>
<th>CCT/Okanogan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smolt release</td>
<td></td>
<td>200,000</td>
<td></td>
</tr>
<tr>
<td>Fertilization-to-release survival</td>
<td></td>
<td>85.9%</td>
<td></td>
</tr>
<tr>
<td>Eggtake target</td>
<td></td>
<td>232,829</td>
<td></td>
</tr>
<tr>
<td>Fecundity</td>
<td></td>
<td>4,982</td>
<td></td>
</tr>
<tr>
<td>Female target</td>
<td></td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Female:male ratio</td>
<td></td>
<td>1:1</td>
<td></td>
</tr>
<tr>
<td>Broodstock target</td>
<td></td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Pre-spawn survival</td>
<td></td>
<td>95.5%</td>
<td></td>
</tr>
<tr>
<td>Total collection target</td>
<td></td>
<td>102</td>
<td>TBD</td>
</tr>
</tbody>
</table>

**Columbia River Mainstem below Wells Dam**

*Summer/fall Chinook*

Summer/fall Chinook mitigation programs that release juveniles directly into the Columbia River between Wells and Rocky Reach dams have traditionally been supported through adult broodstock collections at the Wells Hatchery volunteer channel. Beginning in 2013, the broodstock requirement for the Chelan Falls summer Chinook program will be prioritized through broodstock collection of marked summer Chinook in the Eastbank Outfall (EBO) with the Wells volunteer channel as a back-up collection location should insufficient females be acquired at the EBO. The total production level supported by this collection is up to 576,000 yearlings for the Chelan Falls program.

Collection at the Wells FH volunteer channel will be used to collect the broodstock necessary for the Wells FH yearling (3320,000) and subyearling (484,000) programs. Upon agreement in the HCP-HC, the 2013, summer Chinook broodstock collections at Wells FH may also include up to 266 adults for the USFWS Entiat program pending agreements between USFWS and DCPUD. If approved by the HCP Hatchery Committee, Adults for the Entiat program will be transferred to Entiat NFH by either WDFW or USFWS staff (arrangements between USFWS and DCPUD will have been made prior to implementation).

Adults returning from the Wells and Chelan Falls programs are to support harvest opportunities and are not intended to increase natural production and have been termed segregated harvest programs. These programs have contributed to harvest opportunities (Chelan Falls to a much lesser degree); however, adults from these programs have been documented contributing to adult spawning escapement in tributaries upstream and downstream from their release locations. Because of CCT concerns about sufficient natural origin fish reaching spawning grounds and to ensure sufficient NOR’s being available to meet the CCT summer Chinook program, incorporation of natural origin fish for the Wells program or programs with broodstock...
originating from the Wells volunteer channel, will be limited to fish collected in the Wells volunteer channel. The following broodstock collection protocol was developed based on mitigation objectives and program assumptions (Table 9).

WDFW will target 544 run-at-large summer Chinook from the volunteer ladder trap at Wells Fish Hatchery outfall for the Wells sub-yearling and yearling programs, 116 for the YN Yakima summer Chinook program, and 266 for the USFWS Entiat summer Chinook program. Due to fish health concerns associated with the volunteer collection site (warming Columbia River water during late August), the volunteer collection will begin 11 July and terminate by 31 August. Age-3 males ("jacks") will not be collected for broodstock.

For 2013, broodstock collection for the Chelan Falls summer Chinook program will be prioritized at the Eastbank Outfall using in-channel seining/netting beginning July 1 (or earlier if summer Chinook are detected in the outfall) through September 15. While preliminary evaluations of feasibility late in 2012 did demonstrate the ability to collect summer Chinook, the catch was comprised primarily of males. Given concerns about acquiring sufficient females to meet production objectives, if the number of females has not been reached by August 15, the broodstock collection will default to the Wells Volunteer channel to make up the difference. The 2013 broodstock target for the Chelan Falls program is 318 adults. Age-3 males will not be incorporated into the broodstock. Confirmation of gender will be made at the time of collection using established ultrasonography techniques.

Table 9. Assumptions and calculations to determine the number of broodstock needed for summer/fall Chinook production goals for programs released at or below Wells Dam relying on adult collection at Wells Dam or Wells Hatchery in 2013.

<table>
<thead>
<tr>
<th>Program Assumptions</th>
<th>Standard</th>
<th>Wells FH</th>
<th>Chelan Falls FH</th>
<th>Yakama Nation</th>
<th>USFWS²</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sub-yearling</td>
<td>Yearling</td>
<td>Sub-yearling</td>
<td>Yearling</td>
<td>Green eggs</td>
<td>Adults</td>
</tr>
<tr>
<td>Smolt release</td>
<td>484,000</td>
<td>320,000</td>
<td>576,000</td>
<td>NA</td>
<td>1,957,775</td>
<td></td>
</tr>
<tr>
<td>Green egg-to-release survival</td>
<td>76.1%</td>
<td>83.6%</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggtake target</td>
<td>636,005</td>
<td>382,775</td>
<td>688,995</td>
<td>250,000</td>
<td>1,957,775</td>
<td></td>
</tr>
<tr>
<td>Fecundity</td>
<td>4,487</td>
<td>4,487</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female target</td>
<td>142</td>
<td>86</td>
<td>154</td>
<td>56</td>
<td>438</td>
<td></td>
</tr>
<tr>
<td>Female:Male ratio</td>
<td>1:1</td>
<td>1:1</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broodstock target</td>
<td>284</td>
<td>242</td>
<td>308</td>
<td>112</td>
<td>946</td>
<td></td>
</tr>
<tr>
<td>Pre-spawn survival</td>
<td>96.8%</td>
<td>96.8%</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total collection target</td>
<td>294</td>
<td>250</td>
<td>318</td>
<td>116</td>
<td>266</td>
<td>1,244</td>
</tr>
</tbody>
</table>

¹-The Wells volunteer trap will only be a fallback broodstock source should efforts to acquire broodstock in the Eastbank outfall not provide sufficient females to meet production objectives.
²-Adults for USFWS summer Chinook program in the Entiat River Basin.
³- Includes 70 adults collected for the Lake Chelan triploid Chinook program.
Spring Chinook

In 2013 the Eastbank Fish Hatchery (FH) is expecting to rear spring Chinook salmon for the Chiwawa River and Nason Creek acclimation facilities located on the Chiwawa River and Nason Creek (2013 represents the first brood year production for the new Nason Creek program). The program production level target for the Chiwawa program in 2013 is 144,026 smolts, requiring a total broodstock collection of 74 natural origin spring Chinook (Table 10).

The spring Chinook production obligation for Grant PUD in the Wenatchee Basin is 223,670 smolts. Grant PUD’s production was originally scripted to be met through a combination of 74,556 smolts in the White River and 149,114 smolts at Nason Creek. Consistent with agreements in the PRCC-PC SOA 2013-01, the White River production will be met through progeny produced at Nason Creek through 2026. Because two brood years remain in the White River captive brood program, the PRCC SOA identifies a credit of 75,000 smolts from the captive brood program toward meeting the over 223K production obligation. Additionally, if the 2013 Nason program is unable to meet the balance of the production, any additional production from the 2013 captive brood program will be credited to Grant PUD.

2013 represents the proof of concept year in determining the effectiveness of utilizing Tumwater Dam and genetic assignment methodologies to target broodstock for the Nason Creek spring Chinook program and by default for the Chiwawa spring Chinook program as well. While the Chiwawa program could be met through adult collections solely at the Chiwawa Weir without the use of Tumwater Dam, the Chiwawa NOR component makes up the preponderance of the NOR return in the Wenatchee Basin (~61% of the total return and ~72% of the Chiwawa/Nason aggregate based upon a 10-year geometric mean). As a direct result of targeting NOR’s for Nason Creek, generally, more than sufficient numbers of Chiwawa fish will be handled (and retained at Eastbank FH pending genetic assignments) to meet the Chiwawa program needs. To limit excessive handling of fish (being transported to EB, sampled, transported back to the river, and subsequently intercepted at the Chiwawa Weir and transported back to EB FH or upriver of the weir as per current protocol) which could contribute to handling mortality and to limit delaying fish as a result of the handling and operation of the weir, the JFP prefer to have collections for both programs occur at Tumwater Dam. If use of Tumwater Dam demonstrates a risk to the Wenatchee Basin population which is unacceptable to co-managers and permitting authorities as a result of broodstock collection, alternate and other existing brood collection locations/methods will be considered.
Table 10. Assumptions and calculations to determine the number of broodstock needed for a combined Nason/Chiwawa spring Chinook production goal of 367,696 smolts. For 2013, the Nason Creek production will be met through a combination of smolts produced through one of two remaining captive brood years and the Nason Creek conservation program.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Standard</th>
<th>Conservation</th>
<th>Conservation</th>
<th>Safety net</th>
<th>Wenatchee Basin Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Smolt Release</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilization-to-release survival</td>
<td>85.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total egg take target</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg take (production)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cull allowance</td>
<td>13.1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fecundity</td>
<td>4,684 W</td>
<td>4,14 W H</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Female Target</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female to male ratio</td>
<td>1:1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Broodstock target</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-spawn survival</td>
<td>97.7%W/97.7%H</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total broodstock collection</strong></td>
<td>74W</td>
<td>64W</td>
<td>66H</td>
<td></td>
<td>(138W:66H)</td>
</tr>
</tbody>
</table>

Because Nason Creek is a new program beginning with the 2013 brood, hatchery performance values from the Chiwawa program were used as a surrogate to estimate the adult requirements for Nason Creek.

Inclusion of natural origin fish into the broodstock will be a priority, with natural origin fish specifically being targeted. Consistent with ESA Section 10 Permit 1196, natural origin fish collections will not exceed 33 percent of the return.

Pre-season estimates project a total of 2,732 (521 natural origin (19%) and 2,211 hatchery origin (81%) spring Chinook back to the Wenatchee Basin. Approximately 2,514 spring Chinook are destined for the Chiwawa River, of which 303 (12.1%) and 2,211 fish (87.9%) are expected to be natural and hatchery origin spring Chinook, respectively and approximately 110 natural origin spring Chinook are expected back to Nason Creek (Tables 11 and 12). These protocols, target anywhere between 110 and 175 spring Chinook to be trapped at Tumwater Dam and transported to Eastbank FH for broodstock purposes. In-season assessment of the magnitude and origin composition of the spring Chinook return above Tumwater Dam will be used to provide in-season adjustments to hatchery/wild composition and total broodstock collection, consistent with ESA Section 10 Permit 1196.
Table 11. BY 2008-2010 age class return projection for wild spring Chinook above Tumwater Dam during 2013.

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Nason Cr. Basin&lt;sup&gt;L&lt;/sup&gt;</th>
<th>Chiwawa Basin&lt;sup&gt;L&lt;/sup&gt;</th>
<th>Wenatchee Basin above Tumwater Dam&lt;sup&gt;L&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age-3</td>
<td>Age-4</td>
<td>Age-5</td>
</tr>
<tr>
<td>2008</td>
<td>3</td>
<td>175</td>
<td>31</td>
</tr>
<tr>
<td>2009</td>
<td>2</td>
<td>76</td>
<td>18</td>
</tr>
<tr>
<td>2010</td>
<td>3</td>
<td>122</td>
<td>21</td>
</tr>
<tr>
<td>Estimated Return</td>
<td>3</td>
<td>76</td>
<td>31</td>
</tr>
</tbody>
</table>

<sup>1/-</sup>Based upon average age-at-return (return year 2007-2011), for natural origin spring Chinook above Tumwater Dam (WDFW unpublished data).

<sup>2/-</sup>Mean Chiwawa spring Chinook SAR to the Wenatchee Basin (BY 1998-2003; WDFW unpublished data).

Table 12. BY 2008-2010 age class return projection for Chiwawa hatchery spring Chinook above Tumwater Dam during 2013.

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Smolt Estimate</th>
<th>Adult Returns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chiwawa&lt;sup&gt;1/&lt;/sup&gt;</td>
<td>Age-3&lt;sup&gt;2/&lt;/sup&gt;</td>
</tr>
<tr>
<td>2008</td>
<td>609,789</td>
<td>1,229</td>
</tr>
<tr>
<td>2009</td>
<td>438,651</td>
<td>411</td>
</tr>
<tr>
<td>2010</td>
<td>346,248</td>
<td>245</td>
</tr>
<tr>
<td>Estimated 2013 Return</td>
<td>245</td>
<td>1,827</td>
</tr>
</tbody>
</table>

<sup>1/-</sup>Chiwawa smolt release (Hillman et al. 2013).

<sup>2/-</sup>Based on average age-at-return for hatchery origin spring Chinook above Tumwater Dam, 2006-2010 (WDFW, unpublished data) and total estimated BY return.

<sup>3/-</sup>Mean Chiwawa hatchery spring Chinook SAR to the Wenatchee Basin (BY 1998-2003).

<sup>4/-</sup>Mean Chiwawa hatchery spring Chinook SAR to the Wenatchee Basin (BY 2000-2004).

<sup>5/-</sup>Mean Chiwawa hatchery spring Chinook SAR to the Wenatchee Basin (BY 2001-2005).

Pending issuance of a Section 10 permit for the Nason Creek program, broodstock collection at Tumwater Dam will begin 01 June and terminate no later than 15 August. Spring Chinook trapping at Tumwater Dam if operated independent of the Spring Chinook Reproduction Success Study, will follow a three day per week and up to 16 hours per day and will be consistent with weekly broodstock collection quotas that approximate the historical run timing and a maximum 33 percent retention of the projected natural-origin escapement. If the weekly quota is attained prior to the end of the trapping period, broodstock trapping will cease. If the weekly quota is not attained within the trapping period, the shortfall will carry forward to the next week.

Age-3 males (“jacks”) will not be collected for broodstock.

Based upon these forecasts and assumptions, four options or alternatives for Wenatchee Basin spring Chinook were developed for discussion by the HCP-HC and PRCC-HSC (Table 13). By conference call on 4/9/13, the parties agreed to implement broodstock collection under alternative 3.
Approximately 172 natural origin spring Chinook adults (86 females and 86 males) will be collected at Tumwater Dam (about 33% of the overall NOR return) through duration of the return and transferred to Eastbank FH for holding until a genetic assignments can be made to spawning aggregates (specifically Nason and Chiwawa). This should result in approximately 147 probable Nason/Chiwawa origin adults. Using an 86% probability assignment rate derived through a recent SNP’s evaluation of Wenatchee spring Chinook spawning aggregates, an estimated 36 Nason and 111 Chiwawa NOR’s would be identified (Table 13). The 36 Nason and 74 of the Chiwawa spring Chinook would be retained. All remaining adults either in excess of program needs or individuals not assigning to the two spawning aggregates, would be released at locations, yet to be determined above Tumwater Dam (this is to provide some offset to the delay in migration to the spawning grounds experienced by holding adults at Eastbank FH while the genetic evaluations are being conducted).

Under this alternative full production for the Chiwawa spring Chinook conservation program (144,026 smolts; Table 13) will be met. Should the NOR return fall short of expectations or if insufficient broodstock assign to the Chiwawa, additional trapping at the Chiwawa Weir for NOR’s or possibly HOR’s (to ensure the production level is attained) may be considered by the HCP-HC.

The Nason Creek program should achieve an estimated smolt production of 71,665 conservation program smolts (57% of the conservation program and 48% of the 2013 production target for Nason Creek). This will result in an additional 77,005 smolts (152,005 total) from the 2013 White River captive brood program being credited toward Grant PUD’s Wenatchee Spring Chinook production obligation. The 2013 WR captive brood program is expected to produce approximately 259,297 smolts (Table 16). Should the NOR return fall short of expectations or if insufficient broodstock assign to Nason Creek, additional smolts may be credited to the Nason Creek program from the White River captive brood program consistent with agreements in PRCC-PC SOA 2013-01.

Table 13. Options for broodstock collection of spring Chinook for Nason and Chiwawa programs in 2013.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>NOR’s Retained</th>
<th># Probable Nason/Chiwawa</th>
<th>Chiwawa Broodstock</th>
<th>%</th>
<th>Smolts</th>
<th>Nason Broodstock</th>
<th>%</th>
<th>Smolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>140</td>
<td>119</td>
<td>74</td>
<td>0.244</td>
<td>144,026</td>
<td>29</td>
<td>0.264</td>
<td>55,740</td>
</tr>
<tr>
<td>2</td>
<td>138</td>
<td>115</td>
<td>71</td>
<td>0.191</td>
<td>135,368</td>
<td>29</td>
<td>0.209</td>
<td>43,795</td>
</tr>
<tr>
<td>3</td>
<td>172</td>
<td>147</td>
<td>74</td>
<td>0.244</td>
<td>144,026</td>
<td>36</td>
<td>0.327</td>
<td>71,665</td>
</tr>
<tr>
<td>4</td>
<td>175</td>
<td>149</td>
<td>74</td>
<td>0.244</td>
<td>144,026</td>
<td>36</td>
<td>0.327</td>
<td>71,665</td>
</tr>
</tbody>
</table>

\(^{1/}\) The number of adults retained which are of probable Nason or Chiwawa origin. The difference between the number of probable and the number of NOR’s retained are fish of probable White, Little Wenatchee, and Upper Wenatchee river spawning aggregates. These fish will be returned to river at some location(s) above Tumwater Dam.

\(^{2/}\) The number of broodstock are those individuals which assign to either Nason or Chiwawa. The difference between the total of broodstock and the number of probable Nason/Chiwawa are fish which did not assign at the C.I. agreed to by the parties (using SNP’s methodology) and/or adults in excess of one or both programs. These fish will be returned to river at some location(s) above Tumwater Dam.

\(^{3/}\) This is the proportion of broodstock retained for spawning to the estimated total return of the respective spawning aggregates to Tumwater Dam.
Broodstock collection will start at Tumwater Dam on or about the week beginning June 16. Weekly broodstock goals were developed based upon targeting the middle 90% of the spring Chinook return (Table 14). Due to variability in run timing between years, adjustments may be made in-season using passage of spring Chinook at Rock Island Dam, the lower Wenatchee PIT tag array, and passage of spring Chinook over Tumwater Dam as considerations. If the weekly quota is attained prior to the end of the trapping period, broodstock trapping will cease. If the weekly quota is not attained within the trapping period, the shortfall will carry forward to the next week.

Table 14. Weekly target of natural origin adult spring Chinook for Nason Creek and Chiwawa River conservation programs in 2013.

<table>
<thead>
<tr>
<th></th>
<th>6/23</th>
<th>6/30</th>
<th>7/7</th>
<th>7/14</th>
<th>7/27</th>
<th>7/28</th>
<th>8/4</th>
<th>8/11</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>5</td>
<td>10</td>
<td>16</td>
<td>14</td>
<td>11</td>
<td>9</td>
<td>12</td>
<td>9</td>
<td>86</td>
</tr>
<tr>
<td>Males</td>
<td>5</td>
<td>10</td>
<td>16</td>
<td>14</td>
<td>11</td>
<td>9</td>
<td>12</td>
<td>9</td>
<td>86</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>20</td>
<td>32</td>
<td>28</td>
<td>22</td>
<td>18</td>
<td>24</td>
<td>18</td>
<td>172</td>
</tr>
</tbody>
</table>

**Trapping**

Because broodstock collection will initially run concurrent with the Reproductive Success Studies (RSS) already taking place at Tumwater Dam, we will initially target brood collection on a Monday – Friday time frame to more closely fit with Hatchery staff scheduling.

Trapping at Tumwater Dam will be consistent with operational protocols developed and implemented for the 2011 (Appendix C) and 2012 (Appendix D) trapping seasons and anticipated to continue in 2013 (pending NMFS and USFWS concurrence). If broodstock collection occurs outside of activities under the RSS, trapping will default to Section 10 Permit 1196 conditions of no more than 3-days per week up to 16 hours per day (48 cumulative hours per week).

On each day of trapping, at least one hatchery personnel will be on site with a transport vehicle complete with recirculation ability and oxygen/stones. As RSS personnel work up a wild fish, gender ID will be made using a Honda 110V portable ultrasound machine, DNA (fin clips) will be collected and each fish will receive a PIT tag in the pelvic girdle. To facilitate the timely processing of fish through the Tumwater facility, hatchery personnel will take fish identified for broodstock from RSS staff and place it into the transport truck. At no time will broodstock be placed into or held in temporary tanks on the deck. When an appropriate number of fish have been loaded onto the transport truck (this number will depend upon the size and type of vehicle) or if the weekly broodstock quota has been met, fish will be transported to Eastbank FH (EBFH) for holding. All fish transfers will occur water to water.

**Adult Holding/Sorting**

Up to four adult raceways are expected to be utilized for holding and sorting spring Chinook collected for broodstock. As the first weeks collection is completed, (and placed into a single
raceway) genetic samples will be submitted to the genetics lab in Olympia for processing. Preliminarily we anticipate approximately one to two weeks for the samples to be run and results available. During holding, fish will only receive formalin treatments to prevent external fungus. Antibiotics and other treatments will only be used on broodstock.

When assignments have been provided, hatchery and M&E staff will sort by PIT tag. Fish to be retained for broodstock will be placed into their respective vessels (i.e., Chiwawa in one pond and Nason in another). All remaining fish will be placed onto transport trucks depending upon their assignment. Fish assigning to a respective tributary will be released into that tributary or as closely as possible to mitigate for any delay in migration resultant from holding them at EBFH. Fish that do not assign to any tributary will be released at the Swift Water campground (RKM yet to be determined), well above Tumwater Dam.

Using PIT tags (and possible carcass recoveries), fish not retained for broodstock and released, will be evaluated for post release behavior, survival and spawning success when possible.

**Chiwawa Program Contingencies**

Should the Nason Creek program not receive a Section 10 Permit in time to begin implementation in 2013, contingency plans have been requested for implementation of the Chiwawa Program. The two plans are as follows (either of these still require concurrence by the HCP-HC):

1. **Continue to trap at Tumwater Dam for the Chiwawa program.** The total number of fish collected would be reduced to 140 adults. Under the same assumptions as implementation of alternative 3 will yield the estimated 74 adults needed to meet the Chiwawa conservation program.

   Under this contingency, handling, transporting, and holding of non-target spring Chinook spawning aggregates will occur.

2. **Trap operations would occur at the Chiwawa Weir.** The total number of fish collected would be 74 adults.

   Under this contingency, operation of the weir will result in double handling of wild and hatchery adults in excess to the Chiwawa program. This is due to the presence of the RSS at Tumwater Dam. In addition, the USFWS has expressed concern over bull trout impacts and potential delays to bull trout at the weir.

**Steelhead**

The steelhead mitigation program in the Wenatchee Basin use broodstock collected at Dryden and Tumwater dams located on the Wenatchee River. Per ESA section 10 Permit 1395
provisions, broodstock collection will target adults necessary to meet a 50% natural origin –
conservation oriented program and a 50% hatchery origin – safety net program, not to exceed
33% of the natural origin steelhead return to the Wenatchee Basin. Based on these limitations
and the assumptions listed below (Table 15), the following broodstock collection protocol was
developed.

WDFW will retain a total of 130 mixed origin steelhead for broodstock for a smolt release
objective of 247,300 smolts (Table 14). The 66 hatchery origin adults will be targeted at Dryden
Dam and if necessary Tumwater dam. The 64 natural origin adults will be targeted for collection
at Tumwater Dam. Collection will be proportional to return timing between 01 July and 12
November. Collection may also occur between 13 November and 3 December at both traps,
concurrent with the Yakama Nation coho broodstock collection activities. Hatchery x wild and
hatchery x hatchery parental cross and unknown hatchery parental cross adults will be excluded
from the broodstock collection. Hatchery steelhead parental origins will be determined through
evaluation of VIE tags, adipose/cwt presence/absence, and PIT tag interrogation during
collection. Adult return composition including number, origin, age structure, and sex ratio will
be assessed in-season at Priest Rapids and at Dryden Dam. In-season Broodstock collection
adjustments may be made based on this monitoring and evaluation. To better assure achieving
the appropriate females equivalents for program production, the collection will implement the
draft Production Management Plan, including ultrasonography to determine the sex of each fish
retained for broodstock.

In the event steelhead collections fall substantially behind schedule, WDFW may
initiate/coordinated adult steelhead collection in the mainstem Wenatchee River by hook and
line. In addition to trapping and hook and line collection efforts, Tumwater and Dryden dams
may be operated between February and early April the subsequent spring to supplement
broodstock numbers if the fall trapping effort provides fewer than the required number of adults.
Table 15. Assumptions and calculations to determine the number and origin of 2014 brood Wenatchee summer steelhead broodstock needed for Wenatchee Basin program release of 247,300 smolts.

<table>
<thead>
<tr>
<th>Program Assumptions</th>
<th>Standard</th>
<th>Conservation</th>
<th>Safety Net</th>
<th>Full Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smolt Release</td>
<td>123,650</td>
<td>123,650</td>
<td></td>
<td>247,300</td>
</tr>
<tr>
<td>Fertilization-to-release survival</td>
<td>70.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg take target</td>
<td>176,140</td>
<td>176,140</td>
<td></td>
<td>352,280</td>
</tr>
<tr>
<td>Fecundity</td>
<td>5,930 H</td>
<td>5,787 W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female Target</td>
<td>31</td>
<td>30</td>
<td>32 H</td>
<td>31 W</td>
</tr>
<tr>
<td>Female to male ratio</td>
<td>1:1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broodstock target</td>
<td>62</td>
<td>60</td>
<td></td>
<td>122</td>
</tr>
<tr>
<td>Pre-spawn survival</td>
<td>90.7%H/97.1%W</td>
<td>64</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Total broodstock collection</td>
<td></td>
<td></td>
<td></td>
<td>130</td>
</tr>
</tbody>
</table>

Summer/fall Chinook

Summer/fall Chinook mitigation programs in the Wenatchee River Basin utilize adult broodstock collections at Dryden and Tumwater dams, incubation/rearing at Eastbank Fish Hatchery (FH) and acclimation/release from the Dryden Acclimation Pond. The total production level target for BY 2013 is 500,001 smolts (181,816 GCPUD mitigation and 318,185 CCPUD mitigation).

The TAC 2013 Columbia River UCR summer Chinook return projection to the Columbia River (Appendix A) and BY 2008, 2009 and 2010 spawn escapement to the Wenatchee River indicate sufficient summer Chinook will return to the Wenatchee River to achieve full broodstock collection for the Wenatchee River summer Chinook supplementation program. Review of recent summer/fall Chinook run-timing past Dryden and Tumwater dam indicates that previous broodstock collection activities have omitted the early returning summer/fall Chinook, primarily due to limitations imposed by ESA Section 10 Permit 1347 to minimize impacts to listed spring Chinook. In an effort to incorporate broodstock that better represent the summer/fall Chinook run timing in the Wenatchee Basin, the broodstock collection will front-load the collection to account for the disproportionate collection timing. Approximately 43% of the summer/fall Chinook destined for the upper Basin (above Tumwater Dam) occurs prior to the end of the first week of July; therefore, the collection will provide 43% of the objective by the end of the first week of July. Weekly collection after the first week of July will be consistent with run timing of summer/fall Chinook during the remainder of the trapping period. With concurrence from NMFS, summer Chinook collections at Dryden Dam may begin up to one week earlier. Collections will be limited to a 33% extraction of the estimated natural-origin escapement to the Wenatchee Basin. Based on these limitations and the assumptions listed below (Table 16), the following broodstock collection protocol was developed.
WDFW will retain up to 256 natural-origin, summer Chinook at Dryden and/or Tumwater dams, including 128 females. To better assure achieving the appropriate females for program production, the collection will implement the draft Production Management Plan, including ultrasonography to determine the sex of each fish retained for broodstock. Trapping at Dryden Dam may begin 01 July and terminate no later than 15 September and operate up to 7-days/week, 24-hours/day. Trapping at Tumwater Dam if needed may begin 15 July and terminate no later than 15 September and operate up to 48 hours per week.

Table 16. Assumptions and calculations to determine the number of 2013 brood Wenatchee summer Chinook salmon broodstock needed for Wenatchee Basin program release of 500,001 smolts.

<table>
<thead>
<tr>
<th>Program Assumptions</th>
<th>Standard</th>
<th>Grant PUD</th>
<th>Chelan PUD</th>
<th>Total Wenatchee Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smolt Release</td>
<td></td>
<td>181,816</td>
<td>318,185</td>
<td>500,001</td>
</tr>
<tr>
<td>Fertilization-to-release survival</td>
<td>77.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg take target</td>
<td>233,997</td>
<td>409,505</td>
<td></td>
<td>643,502</td>
</tr>
<tr>
<td>Fecundity</td>
<td>5,085</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female Target</td>
<td>46</td>
<td>80</td>
<td></td>
<td>126</td>
</tr>
<tr>
<td>Female to male ratio</td>
<td></td>
<td>1:1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broodstock target</td>
<td>92</td>
<td>160</td>
<td></td>
<td>252</td>
</tr>
<tr>
<td>Pre-spawn survival</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total broodstock collection</td>
<td>94</td>
<td>162</td>
<td>256</td>
<td></td>
</tr>
</tbody>
</table>

White River Spring Chinook Captive Brood

Smolt production associated with the White River Captive Broodstock Program (75,000 smolts) is linked to implementation of the smolt production objective associated with the Nason Creek adult supplementation program and consistent with the PRCC-PC SOA 2013-01. Spawning, incubation, rearing acclimation and release will be consistent with provisions of (expired) ESA Permit 1592.

Table 17. Estimated smolt production for BY13 and BY14 White River captive brood program at Little White Salmon National Fish Hatchery based upon 5% adult female mortality per month to spawning.

<table>
<thead>
<tr>
<th>Spawn Year</th>
<th>Release Year</th>
<th>Females Spawned</th>
<th>Green egg take</th>
<th>Smolts</th>
<th>Adjusted smolts 1/</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>2015</td>
<td>346,92,439</td>
<td>526,225</td>
<td>384,144</td>
<td>252,610</td>
</tr>
<tr>
<td>2014</td>
<td>2016</td>
<td>0,187,187</td>
<td>224,556</td>
<td>163,926</td>
<td>64,691</td>
</tr>
</tbody>
</table>

1/ Adjusted smolt release numbers are based upon reduced eye-up rates for eggs fertilized with cryo-preserved sperm.
2/ Adjusted for 50% of females crossed with cryo-preserved sperm with a mean eye-up rate of 35%.
3/ Adjusted for 100% of females crossed with cryo-preserved sperm with a mean eye-up rate of 35%.
Priest Rapids Fall Chinook

Collection of fall Chinook broodstock at Priest Rapids Hatchery will generally begin in early September and continue through mid November. Juvenile release objectives specific to Grant PUD (5,325,543 sub-yearlings + 1,000,000 fry), Federal (1,700,000 sub-yearlings + 3,500,000 eggs – collection of broodstock for the federal programs are conditional upon having contracts in place with the ACOE), mitigation commitments. Biological assumptions are detailed in Table 18. Smolt release objectives for Ringold Springs occur as green eggs collected at Priest Rapids FH and incubated at Bonneville prior to eyed-egg transfers to Ringold Springs. After the new Priest Rapids FH rebuild there will no longer be incubation capacity for programs above GCPUD mitigation obligations.

For 2013, some portion of the broodstock may be collected at the OLAFT (as determined/approved by the PRCC-HSC and/or through hook-and-line angling efforts in the Hanford Reach to increase the proportion of natural origin adults in the broodstock to meet integration of the hatchery program. Close coordination between broodstock collections at the volunteer channel, the OLAFT and through hook-and-line efforts in the Hanford Reach will need to occur so over collection is minimized. Presumed NOR’s collected and spawned from either hook-and-line caught broodstock or OLAFT collections will be prioritized for PRH programs (i.e. OLAFT and Hanford Reach fish will be held in a separate raceways from volunteer collected fish and spawned first each week).

Based upon the biological assumptions in Table 15, an estimated 3,264 females will need to be spawned to meet the 12,350,575 eggs required to meet the current three up-river bright (URB) programs which rely on adults collected at the Priest Rapids Hatchery volunteer channel trap, hook-and-line efforts on the Hanford Reach, and/or the Priest Rapids Dam off ladder trap (OLAFT).

To increase the probability of incorporating a higher percentage of NOR’s from the volunteer channel, only adipose present, non-CWT males and females will be retained.

Implementation Assumptions

1) Broodstock may be collected at any or all of the following locations/means: the PRD off ladder trap (OLAFT – specific use to be determined), hook-and-line angling in the Hanford Reach, and the Priest Rapids Hatchery volunteer channel trap.

2) Assumptions used to determine egg/adult needs is based upon current program performance metrics.

3) Broodstock retained from the volunteer channel will exclude age-2 and 3 males (using length at age) to address genetic risks/concerns of younger age-at-maturity males producing offspring which return at a younger age (decreased age-at-maturity) and also decrease the probability of using hatchery origin fish in the broodstock that are skewed towards earlier ages at maturity.
4) Only adipose present, non-CWT males and females will be retained for broodstock from volunteer channel collected broodstock unless a shortage is expected.

5) Only adipose present, non-wired fish encountered through hook-and-line angling and at the OLAFT will be retained for broodstock.

6) All gametes of fish spawned from hook-and-line broodstocking efforts and/or OLAFT collections will be incorporated into the URB programs.

Table 18. Assumptions and calculations to determine the number of fall Chinook salmon broodstock needed for a non-actively integrated Priest Rapids program release of 7,025,543 sub-yearling fall Chinook, 1,000,000 fry and 3,500,000 eggs for Ringold, in 2013.

<table>
<thead>
<tr>
<th>Program Assumptions</th>
<th>Standard</th>
<th>Program objective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Juvenile Production Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grant PUD Mitigation-PUD Funded</td>
<td></td>
<td>5,325,543 smolts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,000,000 fry</td>
</tr>
<tr>
<td>John Day Mitigation-Federally Funded</td>
<td></td>
<td>1,700,000 smolts</td>
</tr>
<tr>
<td>John Day Mitigation ¹-Ringold Springs-ACOE funding.</td>
<td></td>
<td>3,500,000 eggs</td>
</tr>
<tr>
<td><strong>Total Program Objectives</strong></td>
<td></td>
<td>11,525,543 eggs/fry/smolts</td>
</tr>
<tr>
<td><strong>Fertilization-to-release survival</strong></td>
<td>87%</td>
<td>12,724,762</td>
</tr>
<tr>
<td><strong>Egg take target</strong></td>
<td></td>
<td>12,724,762</td>
</tr>
<tr>
<td><strong>Fecundity</strong></td>
<td>4,300</td>
<td></td>
</tr>
<tr>
<td><strong>Female Target</strong></td>
<td></td>
<td>2,959</td>
</tr>
<tr>
<td><strong>Female to male ratio</strong></td>
<td>2:1</td>
<td></td>
</tr>
<tr>
<td><strong>Pre-spawn survival</strong></td>
<td>88%</td>
<td></td>
</tr>
<tr>
<td><strong>Broodstock target</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td>3,363</td>
<td></td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td>1,681</td>
<td></td>
</tr>
<tr>
<td><strong>Total broodstock collection</strong></td>
<td>5,044</td>
<td></td>
</tr>
<tr>
<td><strong>Estimated NOR’s needed</strong></td>
<td>1,530²⁻</td>
<td></td>
</tr>
<tr>
<td><strong>Estimated HOR’s needed</strong></td>
<td>3,514</td>
<td></td>
</tr>
</tbody>
</table>

¹ As of brood year 2009, Priest Rapids Hatchery is taking 3,500,000 eggs for release at Ringold-Meseberg Hatchery funded by the ACOE – incubation of this program occurs at Bonneville.

²⁻ Estimated NOR’s assumes a minimum of 306 wild males using them in the 2:1 F:M ratio and no more than 1,224 wild females. If the number of wild males is increased (the number of NOR females would decrease) or agreements are reached in the PRCC-HSC to use males beyond a 2:1 approach, then the total number of NOR’s required to meet a pNOB=0.4 would be less (the pNOB target applies only to the sub-yearling smolt and Ringold program. The fry program would consist of HxH crosses).
# Appendix A

## Columbia River Mouth Fish Returns Actual and Forecasts

<table>
<thead>
<tr>
<th></th>
<th>2012 Forecast</th>
<th>2012 Return</th>
<th>2013 Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spring Chinook Upriver Total</strong></td>
<td>314,200</td>
<td>203,100</td>
<td>141,400</td>
</tr>
<tr>
<td>Upper Columbia (total)</td>
<td>32,600</td>
<td>24,400</td>
<td>14,300</td>
</tr>
<tr>
<td>Upper Columbia (wild)</td>
<td>2,800</td>
<td>4,800</td>
<td>1,600</td>
</tr>
<tr>
<td>Snake River Spring/Summer (total)</td>
<td>168,000</td>
<td>109,700</td>
<td>58,200</td>
</tr>
<tr>
<td>Snake River (wild)</td>
<td>39,000</td>
<td>33,400</td>
<td>18,900</td>
</tr>
<tr>
<td><strong>Summer Chinook</strong></td>
<td>91,200</td>
<td>58,300</td>
<td>73,500</td>
</tr>
<tr>
<td><strong>Sockeye</strong></td>
<td>462,000</td>
<td>521,000</td>
<td>180,500</td>
</tr>
<tr>
<td>Wenatchee</td>
<td>28,800</td>
<td>59,800</td>
<td>44,600</td>
</tr>
<tr>
<td>Okanogan</td>
<td>431,300</td>
<td>460,600</td>
<td>135,500</td>
</tr>
<tr>
<td>Snake River</td>
<td>1,900</td>
<td>500</td>
<td>1,250</td>
</tr>
</tbody>
</table>

*a/ Numbers may not sum due to rounding*
Appendix B

**DRAFT**

**Hatchery Production Management Plan**

The following management plan is intended to provide life-stage-appropriate management options for Upper Columbia River (UCR) PUD salmon and steelhead mitigation programs. Consistent, significant over-production or under-production risks the PUD’s not meeting the production objectives required by FERC and overages in excess of 110% of program release goals violates the terms and conditions set forth for the implementation of programs under ESA and poses potentially significant ecological risks to natural origin salmon communities.

Under RCW 77.95.210 (Appendix A) as established by House Bill 1286, the Washington Department of Fish and Wildlife has limited latitude in disposing of salmon and steelhead eggs/fry/fish. While this RCW speaks more specifically to the sale of fish and/or eggs WDFW takes a broader application of this statute to include any surplus fish and/or eggs irrespective of being sold or transferred.

We propose implementing specific measures during the different life-history stages to both improve the accuracy of production levels and make adjustments if over-production occurs. These measures include (1) Improved Fecundity Estimates, (2) Adult Collection Adjustments, (3) Within-Hatchery Program Adjustments, and (4) Culling.

**Improved Fecundity Estimates**

A) Develop broodstock collection protocols based upon the most recent 5-year mean in-hatchery performance values for female to spawn, fecundity, Green egg to eye, and green egg to release.

B) Use portable ultrasound units to confirm gender of broodstock collected (broodstock collection protocols assume a 1:1 male-to-female ratio). Ultrasoundography, when used by properly trained staff will ensure the 1:1 assumption is met (or that the female equivalents needed to meet production objective are collected). Spawning matrices can be developed such that if broodstock for any given program are male limited sufficient gametes are available to spawn with the females.

**Adult Collection Adjustments**

C) Make in-season adjustments to adult collections based upon a fecundity-at-length regression model for each population/program and origin composition needs (hatchery/wild). This method is intended to make in-season allowances for the age structure of the return (i.e. age-5 fish are larger and therefore more fecund than age-4 fish), but will also make allowances for age-4 fish that experienced more growth through better ocean conditions compared to an age-5 fish that reared in poorer ocean conditions.
Within-Hatchery Program Adjustments

D) At the eyed egg inventory (first trued inventory), after adjustments have been made for culling to meet BKD management objectives, the over production will be managed in one or more of the following actions as approved by the HCP-HC:

- Voluntary cooperative salmon culture programs under the supervision of the department under chapter 77.100 RCW;
- Regional fisheries enhancement group salmon culture programs under the supervision of the department under this chapter;
- Salmon culture programs requested by lead entities and approved by the salmon funding recovery board under chapter 77.85 RCW;
- Hatcheries of federally approved tribes in Washington to whom eggs are moved, not sold, under the interlocal cooperation act, chapter 39.34 RCW; and

- Governmental hatcheries in Washington, Oregon, and Idaho; or
- Culling for diseases such as BKD and IHN, consistent with the Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State; or
- Distribution to approved organizations/projects for research.

E) At tagging (second inventory correction) fish will be tagged up to 110% of production level at that life stage. If the balance of the population combined with the tagged population amounts to more than 110% of the total release number allowed by Section 10 permits then the excess will be distributed in one or more of the following actions as approved by the HCP-HC:

- Voluntary cooperative salmon culture programs under the supervision of the department under chapter 77.100 RCW;
- Regional fisheries enhancement group salmon culture programs under the supervision of the department under this chapter;
- Salmon culture programs requested by lead entities and approved by the salmon funding recovery board under chapter 77.85 RCW;
- Hatcheries of federally approved tribes in Washington to whom eggs are moved, not sold, under the interlocal cooperation act, chapter 39.34 RCW; and
• Transfer to another resource manager program such as CCT, YN, or USFWS program;

• Governmental hatcheries in Washington, Oregon, and Idaho;

• Placement of fish into a resident fishery (lake) zone, provided disease risks are within acceptable guidelines; or

• Culling for diseases such as BKD and IHN, consistent with the Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State; or

• Distribution to approved organizations/projects for research.

F) In the event that a production overage occurs after the above actions have been implemented or considered, and deemed non viable for fish health reasons in accordance with agency aquaculture disease control regulations (i.e. either a pathogen is detected in a population that may pose jeopardy to the remaining population or other programs if retained or could introduce a pathogen to a watershed where it had not previously been detected) then culling of those fish may be considered.

All provisions, distributions, or transfers shall be consistent with the department's egg transfer and aquaculture disease control regulations as now existing or hereafter amended. Prior to department determination that eggs of a salmon stock are surplus and available for sale, the department shall assess the productivity of each watershed that is suitable for receiving eggs.