

# HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

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**Hatchery Program:**

Upper Yakima Spring Chinook /  
Cle Elum Supplementation and Research Facility  
(CESRF)

**Species or  
Hatchery Stock:**

Spring Chinook

**Agency/Operator:**

Yakama Nation (lead agency)  
In cooperation with WDFW  
And BPA as funding agency

**Watershed and Region:**

Yakima River Basin

**Date Submitted:**

May 2010

**Date Last Updated:**

April 2004; Updated July 26, 2005;  
December 14, 2007; December 11, 2009

## **SECTION 1. GENERAL PROGRAM DESCRIPTION**

### **1.1) Name of hatchery or program.**

Upper Yakima Spring Chinook / Cle Elum Supplementation and Research Facility (CESRF)

Brief Description: Integrated recovery program. Uses wild/natural broodstock collected at Roza Dam to produce approximately 720,000 smolts annually for release at three upper Yakima Basin acclimation sites. In addition, a “hatchery control (HC)” line is maintained for research purposes. The HC line is maintained by collecting hatchery-origin broodstock at Roza Dam to produce approximately 90,000 smolts annually for release at the Clark Flat acclimation site (near Thorp, WA). All HC fish are differentially marked and all adult (age 3-5) returns are captured at Roza and either used for next generation HC broodstock or for tribal subsistence; NO HC fish are allowed to spawn naturally above Roza Dam.

The CESRF program is an adaptively managed supplementation program designed “to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining the long-term genetic fitness of the fish population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits” (BPA 1996). As such, information gained by the program may be used to modify future program operations. The program may also be modified as research questions are answered and there is no longer a need for certain aspects of the program.

### **1.2) Species and population (or stock) under propagation, and ESA status.**

*State common and scientific names.*

Upper Yakima Spring Chinook salmon (*Oncorhynchus tshawytscha*)

ESA Status: Not listed and not a candidate for listing

### **1.3) Responsible organization and individuals**

*Indicate lead contact and on-site operations staff lead.*

**Name (and title):** Charles R. Strom, CESRF Hatchery Manager (on-site operations)  
Dr. David E. Fast, YKFP Research Manager – YN (lead contact)  
Andrew Murdoch, YKFP Research Manager - WDFW  
Melvin Sampson, YKFP Project Manager - YN  
John Easterbrooks, YKFP Project Manager - WDFW

**Agency or Tribe:** Yakama Nation / WDFW

**Address:** 800 Spring Chinook Way, P.O. Box 836, Cle Elum, WA 98922

**Telephone:** (509) 674-3703

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**Email:** C. Strom (osprey@qwestoffice.net), D. Fast (fast@yakama.com)

**Other agencies, Tribes, co-operators, or organizations involved, including contractors, and extent of involvement in the program:**

<b>Co-operators</b>	<b>Role</b>
Washington Department of Fish & Wildlife	Co-Sponsor of Cle Elum Supplementation and Research Facility
Bonneville Power Administration	Funding Source/Administrator
NOAA Fisheries	Research Co-operator
International Statistical Training and Technical Services, Inc	Research Co-operator
Oncorh Consulting	Research Co-operator
U.S. Fish and Wildlife Service	Fish Health consultation and analysis
U.S. Bureau of Reclamation	Co-operator for juvenile and adult monitoring at Prosser and Roza Dams

**1.4) Funding source, staffing level, and annual hatchery program operational costs.**

Bonneville Power Administration (NPCC Fish & Wildlife Program)

Cle Elum Facility: 8.5 full-time, \$1,500,000 Budget

YKFP Yakima Basin Research, Monitoring and Evaluation (including fall Chinook and coho, and WDFW ecological interactions): ~10-12 full-time biologists, ~10-12 full-time technicians, annual budget ~\$4.5 million

**1.5) Location(s) of hatchery and associated facilities.**

*Include name of stream, river kilometer location, basin name, and state. Also include watershed code (e.g. WRIA number), regional mark processing center code, or other sufficient information for GIS entry. See "Instruction E" for guidance in responding.*

<b>Broodstock source</b>	Upper Yakima Spring Chinook
<b>Broodstock collection location (stream, RKm, subbasin)</b>	Roza Adult Monitoring Facility (Roza Dam), Yakima River, 205.8 RKm, Yakima subbasin
<b>Adult holding location (stream, RKm, subbasin)</b>	CleElum SRF, Yakima River, 295.5 RKm, Yakima subbasin
<b>Spawning location (stream, RKm, subbasin)</b>	CleElum SRF, Yakima River, 295.5 RKm, Yakima subbasin
<b>Incubation location (facility name, stream, RKm, subbasin)</b>	CleElum SRF, Yakima River, 295.5 RKm, Yakima subbasin
<b>Rearing location (facility name, stream, RKm, subbasin)</b>	CleElum SRF, Yakima River, 295.5 RKm, Yakima subbasin

Returning adult spring Chinook are sampled and broodstock collected at the Roza adult monitoring facility located on the Yakima River (Rkm 205.8). The CESRF is approximately 1.5 miles southwest of the City of Cle Elum, Washington. The site is located in Sections 27, 28, 33, and 34, Township 20 North, Range 15 East, Willamette Meridian. The hatchery is on the left bank of the Yakima River at river mile 184.7. The address is: 800 Spring Chinook Way, P.O. Box 836, Cle Elum, WA 98922.

The Easton acclimation site is approximately 12.5 miles northwest of the City of Cle Elum, north of Interstate 90 at exit 71. The site is located in section 12, Township 20 North, Range 13 East, Willamette Meridian. The Easton acclimation site is on the right bank of the Yakima River at river mile 198.6. The address is: 44 Tree Farm Road, Easton, WA 98925.

The Clark Flat acclimation site is approximately 12.6 miles southeast of the City of Cle Elum on an extension of Dudley Road off Thorp Highway. The site is located in Sections 28 and 33, Township 19 North, Range 17 East, Willamette Meridian. The Clark Flat acclimation site is on the left bank of the Yakima River at river mile 166.6. The address is: 1500 Dudley Road, Thorp, WA 98946.

The Jack Creek acclimation site is approximately 20.3 miles north of the City of Cle Elum on North Fork Teanaway Road. The site is located in section 8, Township 21 North, Range 16 East, Willamette Meridian. The Jack Creek acclimation site is on the left bank of the North Fork Teanaway River at river mile 6.4. The address is: 20201 North Fork Teanaway Road, Cle Elum, WA 98922.

#### **1.6) Type of program.**

*Define as either: Integrated Recovery; Integrated Harvest; Isolated Recovery; or Isolated Harvest (see Attachment 1 - Definitions" section for guidance).*

Integrated Recovery.

#### **1.7) Purpose (Goal) of program.**

*Define as either: Augmentation, Mitigation, Restoration, Preservation/Conservation, or Research (for Columbia Basin programs, use NPPC document 99-15 for guidance in providing these definitions of "Purpose"). Provide a one sentence statement of the goal of the program, consistent with the term selected and the response to Section 1.6.*

*Example: "The goal of this program is the restoration of spring Chinook salmon in the White River using the indigenous stock".*

The CESRF has multiple goals including: harvest augmentation, mitigation, restoration, research, and education/outreach. The CESRF was authorized in 1996 under the NPCC's Fish and Wildlife Program with the stated purpose being "to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining the long-term genetic fitness of the fish population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits" (BPA 1996).

Specific Objectives:

Harvest Augmentation, mitigation, restoration: See Appendix Tables A.1 and A.2.

Research:

- 1) Can integrated hatchery programs be used to increase long-term natural production?
- 2) Can integrated hatchery programs limit genetic impacts to non-target chinook populations?
- 3) Can integrated hatchery programs limit ecological impacts to non-target populations?
- 4) Does supplementation increase harvest opportunities?

For detailed information relative to research objectives, monitoring, and evaluation please refer to Appendix A and Busack et al. 1997.

### **1.8) Justification for the program.**

*Indicate how the hatchery program will enhance or benefit the survival of the listed natural population (integrated or isolated recovery programs), or how the program will be operated to provide fish for harvest while minimizing adverse effects on listed fish (integrated or isolated harvest programs).*

Historically, the return of spring Chinook salmon (*Oncorhynchus tshawytscha*) to the Yakima River numbered about 200,000 fish annually (BPA 1990). Spring Chinook returns to the Yakima River averaged fewer than 3,500 fish per year through most of the 1980s and 1990s (less than 2% of the historical run size).

In an attempt to reverse this trend the Northwest Power and Conservation Council (formerly the Northwest Power Planning Council, NPPC) in 1982 first encouraged Bonneville Power Administration (BPA) to “fund the design, construction, operation, and maintenance of a hatchery to enhance the fishery for the Yakima Indian Nation as well as all other harvesters.” (NPPC 1982).

The program is included in the United States versus Oregon 2008-2017 Columbia River Fish Management Plan and the recently signed Columbia River Accords between the Columbia River Tribes and the Bonneville Power Administration. The program is consistent with the Yakima Subbasin Salmon Recovery Plan (Freudenthal et al. 2005).

See also 1.7.

### **1.9) List of program “Performance Standards”.**

*“Performance Standards” are designed to achieve the program goal/purpose, and are generally measurable, realistic, and time specific. The NPPC “Artificial Production Review” document attached with the instructions for completing the HGMP presents a list of draft “Performance Standards” as examples of standards that could be applied for a hatchery program. If an ESU-wide hatchery plan including your hatchery program is available, use the performance standard list already compiled.*

*Example: “(1) Conserve the genetic and life history diversity of Upper Columbia River spring Chinook populations through a 12 year duration captive broodstock program; (2) Augment, restore and create viable naturally spawning populations using supplementation and reintroduction strategies; (3) Provide fish to satisfy legally mandated harvest in a manner which minimizes the risk of adverse effects to listed wild populations; (4)...”.*

Project performance standards and progress towards achieving those standards can be found in the project’s annual reports to BPA which include the report, Natural Production and Domestication Monitoring of the Yakima Spring Chinook Supplementation Program, Yakima/Klickitat Fisheries Project Monitoring Implementation Planning Team, Revised Dec 21, 2005 (attached to this HGMP as Appendix A).

Program performance standards and indicators are centered on the NPCCs definition of

supplementation developed by the Regional Assessment of Supplementation Programs (RASP): "Supplementation is the use of artificial propagation in an attempt to maintain or increase natural production while maintaining the long term fitness of the target population, and keeping the ecological and genetic impacts on non-target populations within specified biological limits" (RASP 1992).

Please reference Tables 1.10.1, 3.5, A.1, A.2, and all of Appendix A in this document for additional detail.

While the project does not actively manage for a specific spawning escapement proportion (natural- to hatchery-origin adults), we are monitoring the proportion of natural influence (PNI; Table 1.12.2). The project will adaptively manage this parameter considering factors such as: policy input regarding surplusing of fish, meeting overall production goals of the project, guidance from the literature relative to percentage of hatchery fish on the spawning grounds with fitness loss, considerations about what risk is acceptable in a project designed to evaluate impacts from that risk, and the numerous risk containment measures already in place in the project. The State of Washington is using mark-selective fisheries in the lower Columbia River and, when possible, in the lower Yakima River in part as a tool to manage escapement proportions.

**1.10) List of program “Performance Indicators”, designated by "benefits" and "risks."**

*“Performance Indicators” determine the degree that program standards have been achieved, and indicate the specific parameters to be monitored and evaluated. Adequate monitoring and evaluation must exist to detect and evaluate the success of the hatchery program and any risks to or impairment of recovery of affected, listed fish populations.*

*The NPPC “Artificial Production Review” document referenced above presents a list of draft “Performance Indicators” that, when linked with the appropriate performance standard, stand as examples of indicators that could be applied for the hatchery program. If an ESU-wide hatchery plan is available, use the performance indicator list already compiled. Essential “Performance Indicators” that should be included are monitoring and evaluation of overall fishery contribution and survival rates, stray rates, and divergence of hatchery fish morphological and behavioral characteristics from natural populations.*

*The list of “Performance Indicators” should be separated into two categories: "benefits" that the hatchery program will provide to the listed species, or in meeting harvest objectives while protecting listed species; and "risks" to listed fish that may be posed by the hatchery program, including indicators that respond to uncertainties regarding program effects associated with a lack of data.*

**1.10.1) “Performance Indicators” addressing benefits.**

*(e.g. “Evaluate smolt-to-adult return rates for program fish to harvest, hatchery broodstock, and natural spawning.”).*

See 1.9 and Appendix A. The project has defined and is tracking performance and trends

relative to 14 adult and 15 juvenile traits. In addition, the project has been using a spawning channel at the CESRF since 2000 to monitor relative reproductive success using DNA micro-satellite analysis of parents and progeny. Also, the project is using snorkeling, electrofishing, and other methods to extensively monitor ecological interactions such as competition, predation, and residualism. The following is a summary of the project's key findings to date relative to these performance indicators of benefits and risks.

The Yakima/Klickitat Fisheries Project (YKFP) is on schedule to ascertain whether new artificial production techniques can be used to increase harvest and natural production of spring Chinook salmon while maintaining the long-term genetic fitness of the fish population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits. The Cle Elum Supplementation and Research Facility (CESRF) collected its first spring Chinook brood stock in 1997, released its first fish in 1999, and age-4 adults have been returning since 2001. In these initial years of CESRF operation, recruitment of hatchery origin fish has exceeded that of fish spawning in the natural environment, but early indications are that hatchery-origin fish are not as successful at spawning in the natural environment as natural origin fish. Preliminary results indicate that significant differences have been detected among hatchery and natural origin fish in about half of the traits measured in our monitoring plan and that these differences can be attributed to both environmental and genetic causes. For example, we have detected differences in hatchery and natural origin fish after only one generation of hatchery exposure for the following variables measured on adults: age composition, size-at-age, sex ratio, spawning timing, fecundity, egg weight, adult morphology at spawning, spawning success. Significant differences in juvenile traits have also been detected: food conversion efficiency, length-weight relationships, agonistic competitive behavior, predator avoidance, and incidence of precocious maturation. Most of the differences have been 10% or less.

Distribution of spawners has increased as a result of acclimation site location and salmon homing fidelity. Semi-natural rearing and predator avoidance training have not resulted in significant increases in survival of hatchery fish. Growth manipulations in the hatchery appear to be reducing the number of precocious males produced by the YKFP and consequently increasing the number of migrants, however post-release survival of treated fish appears to be significantly lower than conventionally reared fish. Genetic impacts to non-target populations appear to be low because of the low stray rates of YKFP fish. Ecological impacts to valued non-target taxa were generally within containment objectives, or impacts that were outside of containment objectives were not caused by supplementation activities. However, we detected impacts to rainbow trout abundance and biomass in 5 treatment and 6 control index sites within the Teanaway Basin. The impacts to rainbow trout were potentially the result of cumulative impacts from hatchery released Chinook salmon smolts, residualized spring Chinook salmon, and an increase in naturally produced parr. However, substantial variation in environmental conditions, and fish and human utilization

of the index areas could also explain the observed differences in abundance and biomass. Fish and bird piscivores consume large numbers of salmonids in the Yakima Basin.

Natural production of Chinook salmon in the upper Yakima Basin appears to be density dependent under current conditions and may constrain the benefits of supplementation. However, such constraints could be countered by YKFP habitat actions that have resulted in: the protection of almost 1,000 acres of prime floodplain habitat, reconnection and screening of over 15 miles of tributary habitat, substantial water savings through irrigation improvements, and restoration of over 80 acres of floodplain and side channels. Additional habitat improvements implemented by other entities, including the Conservation Districts, counties and private interests are also continuing in the basin.

Harvest opportunities for tribal and non-tribal fishers have also been enhanced, but are variable among years. However, quantitative harvest objectives for the upper Yakima stock and all Yakima basin stocks combined have not been met in either the Columbia or Yakima rivers.

The YKFP is still in the early stages of evaluation and as such the data and findings presented in project reports should be considered preliminary until further data is collected and analyses completed. Nonetheless, the YKFP has produced significant findings, and developed methodologies that can be used to evaluate and improve supplementation. Table 1.10.1 provides a summary of topical area performance for the YKFP spring Chinook supplementation program.



Table 1.10.1. Performance of the Yakima Fisheries Project relative to topical performance measures.

<b>Performance Measure</b>	<b>Goal</b>	<b>Performance</b>	<b>Comments</b>
Natural Production of Target Species	Increase while maintaining the long-term fitness of the target population (see Tables A.1 and A.2; Pearsons et al. 2006)	Quantitative objectives have been exceeded but differences in traits of hatchery and natural origin fish are a concern	<ul style="list-style-type: none"> <li>- Too early to evaluate conclusively, but strategies to reduce genetic risk are being implemented.</li> <li>- Hatchery has increased the number and distribution of adult spawners on the spawning grounds. Quantitative management objectives for natural production of upper Yakima and basin total spring Chinook adults have been achieved.</li> <li>- Significant changes in many demographic and reproductive success traits suggest some cause for concern.</li> <li>- Predation and competition may be limiting natural production objectives and may constrain the benefits of supplementation.</li> </ul>
Harvest	Increase (see Tables A.1 and A.2; Pearsons et al. 2006)	Increased, but objectives haven't been met	<ul style="list-style-type: none"> <li>- Tribal subsistence fisheries occurred on both hatchery and naturally produced fish in all years. Sport fisheries on hatchery fish have also occurred in the Yakima River in 3 of the 7 years since 2001.</li> <li>- Quantitative harvest objectives for the upper Yakima stock and all Yakima basin stocks combined have not been met in either the Columbia or Yakima rivers</li> </ul>
Genetics	Minimize genetic impacts to non-target taxa	Achieved to date	Stray rates are very low
Ecology	Keep impacts to non-target taxa within containment objectives (see Pearsons et al. 2006)	Achieved for most taxa to date, but exceeded for steelhead in the Teanaway Basin	Impacts for most species are within containment objectives or are currently not attributable to supplementation. Impacts to steelhead in the Teanaway Basin have potentially exceeded containment objectives.

<b>Performance Measure</b>	<b>Goal</b>	<b>Performance</b>	<b>Comments</b>
Habitat	Protect the most productive stream reaches and increase productivity/capacity of freshwater environment so that quantitative objectives can be achieved.	Progress	Habitat protection, restoration, and tributary passage efforts are ongoing, with incremental progress each year. - Habitat actions should enhance the benefits of supplementation, especially over the long-term.
Science	Disseminate important findings for use throughout the Yakima Basin, Columbia Basin, and world	Achieved to date	Numerous annual reports were submitted to BPA, all tasks were reported on at annual conferences, and manuscripts have been prepared and published.

**1.10.2) “Performance Indicators” addressing risks.**

*(e.g. “Evaluate predation effects on listed fish resulting from hatchery fish releases.”).*

See 1.9, 1.10.1, and Appendix A.

**1.11) Expected size of program.**

*In responding to the two elements below, take into account the potential for increased fish production that may result from increased fish survival rates affected by improvements in hatchery rearing methods, or in the productivity of fish habitat.*

**1.11.1) Proposed annual broodstock collection level (maximum number of adult fish).**

The program uses wild/natural broodstock collected at Roza Dam to produce approximately 720,000 smolts annually for release at three upper Yakima Basin acclimation sites. The number of adults collected annually to produce this release is given in Table 1.11.1. In addition, a “hatchery control (HC)” line is maintained for research purposes. The HC line is maintained by collecting hatchery-origin broodstock at Roza Dam to produce approximately 90,000 smolts annually for release at the Clark Flat acclimation site (near Thorp, WA). All HC fish are differentially marked and all adult (age 3-5) returns are captured at Roza and either used for next generation HC broodstock or for tribal subsistence; NO HC fish are allowed to spawn naturally above Roza Dam.

One of the program’s goals is to collect broodstock from a representative portion of the population throughout the run. If the total run size could be known in advance, collecting brood stock on a daily basis in exact proportion to total brood need as a proportion of total run size would result in ideal run representation. Since it is not possible to know the run size in advance, the CESRF program uses a brood collection schedule that is based on average run timing once

the first fish arrive at Roza Dam. We have found that, while river conditions dictate run timing (i.e., fish may arrive earlier or later depending on flow and temperature), once fish begin to move at Roza, the pattern in terms of relative run strength over time is very similar from year to year. Thus a brood collection schedule matching normal run timing patterns was developed to assure that fish are collected from all portions of the run.

Another program goal is to take no more than 50% of the wild/natural adult return to Roza Dam for broodstock. Given this goal and with a set brood collection schedule at Roza Dam, the project imposed a rule that no more than 50% of the fish arriving on any given day be taken for broodstock. Under-collection relative to the schedule is “carried over” to subsequent days and weeks. This allows brood collection to adjust relative to actual run timing and run strength. Performance across years with respect to these brood collection goals is given in Table 1.11.1.

**Table 1.11.1. Counts of wild/natural spring Chinook (including jacks), brood collection, and brood representation of wild/natural run at Roza Dam, 1997 – present.**

Year	Trap Count	Brood Take	Brood %	Portion of run collected: <sup>1</sup>			Portion of collection from: <sup>2</sup>		
				Early <sup>3</sup>	Middle <sup>3</sup>	Late <sup>3</sup>	Early <sup>3</sup>	Middle <sup>3</sup>	Late <sup>3</sup>
1997	1,445	261	18.1%	26.4%	17.6%	17.7%	7.3%	83.1%	9.6%
1998	795	408	51.3%	51.1%	51.3%	51.9%	5.6%	84.3%	10.0%
1999	1,704	738	43.3%	44.6%	44.1%	35.9%	5.6%	86.3%	8.1%
2000	11,639	567	4.9%	10.7%	4.5%	4.4%	12.5%	77.8%	9.7%
2001	5,346	595	11.1%	6.9%	11.4%	10.7%	3.0%	87.7%	9.2%
2002	2,538	629	24.8%	15.7%	25.2%	26.1%	3.2%	86.3%	10.5%
2003	1,558	441	28.3%	52.5%	25.9%	36.4%	9.5%	77.8%	12.7%
2004	7,804	597	7.6%	2.6%	7.4%	12.8%	2.0%	81.6%	16.4%
2005	5,086	510	10.0%	2.2%	9.5%	21.9%	1.3%	77.0%	21.7%
2006	2,050	419	20.4%	48.5%	22.2%	41.0%	9.1%	75.1%	15.8%
2007	1,293	449	34.7%	25.0%	34.4%	60.6%	3.2%	80.0%	16.9%
2008	1,677	457	27.3%	57.7%	26.7%	32.4%	9.3%	79.0%	11.6%
2009	3,030	486	16.0%	10.0%	14.1%	35.9%	3.5%	73.9%	22.6%

1. This is the proportion of the earliest, middle, and latest running components of the entire wild/natural run which were taken for broodstock. Ideally, this collection percentage would be equal throughout the run and would match the “Brood %”.
2. This is the proportion of the total broodstock collection taken from the earliest, middle, and latest components of the entire wild/natural run. Ideally, these proportions would match the definitions for early, middle, and late given in 3.
3. Early is defined as the first 5% of the run, middle is defined as the middle 85%, and late as the final 10% of the run.

Data source: Bosch 2009.

**1.11.2) Proposed annual fish release levels (maximum number) by life stage and location.** *(Use standardized life stage definitions by species presented in Attachment 2).*

Life Stage	Release Location	Annual Release Level
Eyed Eggs		
Unfed Fry		
Fry		
Fingerling		
Yearling	Described below	~810,000 smolts annually

Acclimation and release sites are located at Easton (rkm 317.8), Clark Flats near the town of Thorp (rkm 266.6), and Jack Creek (approximately 32.5 km north of Cle Elum) on the North Fork Teanaway River (rkm 10.2). Fish are volitionally released at all three sites beginning March 15.

**1.12) Current program performance, including estimated smolt-to-adult survival rates, adult production levels, and escapement levels. Indicate the source of these data.** *Provide estimated smolt-to-adult survival rate, total adult production number, and escapement number (to the hatchery and natural areas) data available for the most recent twelve years (roughly three fish generations), or for the number of years of available and dependable information. Indicate program goals for these parameters.*

The amount of information on this subject is too voluminous and the caveats associated with these data too numerous to describe here. Recent run reconstruction data are given in Table 1.12.1. A summary of natural- and hatchery-origin escapement levels and proportion natural influence parameters for recent years of the project are given in Table 1.12.2. For additional information on smolt-to-adult and adult-to-adult productivity, please refer to Bosch (2009). Also see 1.9, 1.10.1, and Appendix A for a more complete description of program performance.

While the project does not actively manage for a specific spawning escapement proportion (natural- to hatchery-origin adults), we are monitoring the proportion of natural influence (PNI; Table 1.12.2). The project will adaptively manage this parameter considering factors such as: policy input regarding surplusing of fish, meeting overall production goals of the project, guidance from the literature relative to percentage of hatchery fish on the spawning grounds with fitness loss, considerations about what risk is acceptable in a project designed to evaluate impacts from that risk, and the numerous risk containment measures already in place in the project. The State of Washington is using mark-selective fisheries in the lower Columbia River and, when possible, in the lower Yakima River in part as a tool to manage escapement proportions.

**Table 1.12.1. Yakima River spring Chinook run (CESRF and wild, adults and jacks combined) reconstruction, 1983-present.**

Year	River Mouth Run Size <sup>1</sup>			Harvest	Harvest	Spawners	Roza	Roza	Est. Escapement		Redd Counts		
	Adults	Jacks	Total	Below Prosser	Prosser Count	Above Prosser	Count	Removals <sup>3</sup>	Upper Y.R. <sup>4</sup>	Naches <sup>5</sup>	Upper Y.R.	Naches	
1983	1,231	210	1,441	72	867	12	118	1,007	0	1,007	232	360	83
1984	2,251	407	2,658	119	2,539	170	180	1,619	84	1,535	570	634	220
1985	4,109	451	4,560	321	4,239	544	247	2,428	97	2,331	1,020	860	427
1986	8,841	598	9,439	530	8,909	810	709	3,267	16	3,251	4,123	1,472	1,313
1987	4,187	256	4,443	359	4,084	158	269	1,928	194	1,734	1,729	903	677
1988	3,919	327	4,246	333	3,913	111	60	1,575	235	1,340	2,167	424	490
1989	4,640	274	4,914	560	4,354	187	135	2,515	184	2,331	1,517	915	541
1990	4,280	92	4,372	131	2,255	532	282	2,047	31	2,016	1,380	678	464
1991	2,802	104	2,906	27	2,879	5	131		40	1,583	1,121	582	460
1992	4,492	107	4,599	184	4,415	161	39	3,027	18	3,009	1,188	1,230	425
1993	3,800	119	3,919	44	3,875	85	56	1,869	0	1,869	1,865	637	554
1994	1,282	20	1,302	0	1,302	25	10	563	0	563	704	285	272
1995	526	140	666	0	666	79	9	355	0	355	223	114	104
1996	3,060	119	3,179	100	3,079	375	26	1,631	0	1,631	1,047	801	184
1997	3,092	81	3,173	0	3,173	575	20	1,445	261	1,184	1,133	413	339
1998	1,771	132	1,903	0	1,903	188	3	795	408	387	917	147	330
1999	1,513	1,268	2,781	8	2,773	596	55	1,704	738	966	418	212	186
2000	17,519	1,582	19,101	90	19,011	2,368	204	12,327	667	11,660	4,112	3,770	887
2001	21,225	2,040	23,265	1,793	21,472	2,838	286	12,516	718	11,798	5,832	3,260	1,192
2002	14,616	483	15,099	328	14,771	2,780	29	8,922	878	8,044	3,041	2,816	943
2003	4,868	2,089	6,957	59	6,898	381	83	3,842	584	3,258	2,592	868	935
2004	13,974	1,315	15,289	135	15,154	1,544	90	11,005	718	10,287	2,515	3,414	719
2005	8,059	699	8,758	34	8,724	440	28	6,352	667	5,685	1,904	2,009	576
2006	5,951	363	6,314	0	6,314	600	14	4,028	664	3,364	1,672	1,245	444
2007	2,968	1,335	4,303	10	4,293	269	13	3,025	716	2,309	986	722	314
2008	6,615	1,983	8,598	539	8,059	993	9	5,478	1,144	4,334	1,578	1,372	495
2009	7,472	4,648	12,120	1,517	10,603	758	18	8,633	1,595	7,038	1,194	1,527	478
Mean <sup>6</sup>	10,326	1,654	11,980	450	11,530	1,297	77	7,613	835	6,778	2,543	2,100	698

1. River Mouth run size is the greater of the Prosser count plus lower river harvest or estimated escapement plus all known harvest and removals.
2. Estimated as the average number of fish per redd in the upper Yakima times the number of redds between the Naches confluence and Roza Dam.
3. Roza removals include harvest above Roza, hatchery removals, and/or wild broodstock removals.
4. Estimated escapement into the upper Yakima River is the Roza count less harvest or broodstock removals above Roza Dam except in 1991 when Upper Yakima River escapement is estimated as the (Prosser count - harvest above Prosser - Roza subtractions) times the proportion of redds counted in the upper Yakima.
5. Naches River escapement is estimated as the Prosser count less harvest above Prosser and the Roza counts, except in 1982, 1983 and 1990 when it is estimated as the upper Yakima fish/redd times the Naches redd count.
6. Recent 10-year average (2000-2009).

**Table 1.12.2. Escapement (Roza Dam counts less brood stock collection and harvest above Roza) of natural- (NoR) and hatchery-origin (HoR) spring Chinook to the upper Yakima subbasin, 1982 – present.**

Year	Wild/Natural (NoR)			CESRF (HoR)			Total			% HoR	PNI <sup>1</sup>
	Adults	Jacks	Total	Adults	Jacks	Total	Adults	Jacks	Total		
1982			1,146								
1983			1,007								
1984			1,535								
1985			2,331								
1986			3,251								
1987			1,734								
1988			1,340								
1989			2,331								
1990			2,016								
1991			1,583 <sup>2</sup>								
1992			3,009								
1993			1,869								
1994			563								
1995			355								
1996			1,631								
1997	1,141	43	1,184								
1998	369	18	387								
1999	498	468	966								
2000	10,491	481	10,972		688	688	10,491	1,169	11,660	5.9%	
2001	4,454	297	4,751	6,065	982	7,047	10,519	1,279	11,798	59.7%	62.6%
2002	1,820	89	1,909	6,064	71	6,135	7,884	160	8,044	76.3%	56.7%
2003	394	723	1,117	1,036	1,105	2,141	1,430	1,828	3,258	65.7%	60.3%
2004	6,536	671	7,207	2,876	204	3,080	9,412	875	10,287	29.9%	77.0%
2005	4,401	175	4,576	627	482	1,109	5,028	657	5,685	19.5%	83.7%
2006	1,510	121	1,631	1,622	111	1,733	3,132	232	3,364	51.5%	66.0%
2007	683	161	844	734	731	1,465	1,417	892	2,309	63.4%	61.2%
2008	988	232	1,220	2,157	957	3,114	3,145	1,189	4,334	71.9%	58.2%
2009	1,843	701	2,544	2,234	2,260	4,494	4,077	2,961	7,038	63.9%	61.0%
Mean <sup>3</sup>	2,702	322	3,024	2,602	767	3,369	5,116	1,119	6,235	55.8%	65.2%

1. Proportion Natural Influence equals Proportion Natural-Origin Broodstock (PNOB; 1.0 as only NoR fish are used for supplementation line brood stock) divided by PNOB plus Proportion Hatchery-Origin Spawners (PHOS; % HoR).
2. This is a rough estimate since Roza counts are not available for 1991.
3. For NoR columns, mean of 1997-present values. For all other columns, mean of 2001-present values.

Data source for Tables 1.12.1 and 1.12.2: Bosch 2009.

**1.13) Date program started (years in operation), or is expected to start.**

The first year of operation for this hatchery was 1997.

**1.14) Expected duration of program.**

There is no planned termination date. This is a continuing project to meet YKFP and/or Yakima Subbasin Management and Recovery Plan objectives. As stated in the final EIS for the project, “Sustained supplementation may eventually become unnecessary, but

only if substantial improvements in habitat and in-river migration conditions were to reduce significantly the mortality of all salmonid stocks” (BPA 1996).

**1.15) Watersheds targeted by program.**

*Include WRIA or similar stream identification number for desired watershed of return.*

Yakima River Basin (WRIA code 39).

**1.16) Indicate alternative actions considered for attaining program goals, and reasons why those actions are not being proposed.**

Alternatives to the YKFP program were fully evaluated during the Yakima Fisheries Project EIS process and were summarized in the final EIS document (BPA et al. 1996). The program continues to be adjusted, based on the principles of adaptive management adopted by the YKFP.

**SECTION 2. PROGRAM EFFECTS ON NMFS ESA-LISTED SALMONID POPULATIONS. (USFWS ESA-Listed Salmonid Species and Non-Salmonid Species are addressed in Addendum A)**

**2.1) List all ESA permits or authorizations in hand for the hatchery program.**

This document is intended to be consistent with NOAA (2008) which states (RPA 39):  
The FCRPS Action Agencies will continue funding hatcheries in accordance with existing programs... Consultation under the ESA on the operation of hatchery programs funded by the FCRPS Action Agencies [will] include[e] the submittal of updated and complete HGMPs. Updated and complete HGMPs are to be submitted to NOAA Fisheries and ESA consultation should be initiated by ... July 2009 for hatchery programs in the Middle Columbia ... ESA consultations should be completed by January 2010 for hatchery programs in the Middle Columbia ...

Project sponsors are also aware of direction in NOAA (2009) calling “for consultations on hatchery programs within the MCR Steelhead DPS to be completed by January 2010”. Project sponsors remind NOAA of its statement in this document that “mitigation obligations will not be diminished under this process”. The Yakama Nation considers this project essential to meeting federal commitments to honor the Treaty of 1855, and to “protect, rebuild, and enhance” anadromous salmon populations throughout tribal usual and accustomed fishing areas as described in the 2008-2017 *United States v Oregon* Management Agreement and in the Columbia River Fish Accords. As such, any changes to program parameters described herein which would diminish the number of adult salmon returning to tribal usual and accustomed fishing areas that result from this HGMP development and consultation process will not be implemented unless and until they are considered and approved in appropriate policy fora.

The program has the following permits or authorizations:  
Permit # 1426 for handling steelhead at the Roza adult monitoring facility.

YKFP projects have been operating under a "BPA Letter" dated 4/6/01 from Robert Beraud to Rob Jones which states that NMFS has no concern that YKFP activities would violate 7d rules. An electronic copy of the letter is not available but could be mailed via U.S. mail if desired. In addition, the BPA environmental coordinator for the YKFP has prepared NEPA documents which cover all the environmental aspects of the project, including ESA coverage. A final EIS for the project was prepared in 1996 (BPA 1996) and the following supplemental analyses related to spring Chinook activities are also available:

- Yakima-Klickitat Fisheries Project Supplement Analysis, DOE/EIS-0169-SA-01, May 1999
- Supplement Analysis for Yakima Fisheries Project, DOE/EIS-0169-SA-02, August 1999
- Supplement Analysis for Yakima/Klickitat Fisheries Project, (DOE/EIS-0169-SA-05), September 2002

Copies of this documentation can be obtained from Patricia R. Smith ([prsmith@bpa.gov](mailto:prsmith@bpa.gov)), or Rachel Rounds ([rarounds@bpa.gov](mailto:rarounds@bpa.gov)), BPA, 800-282-3713.

**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.**

*Include information describing: adult age class structure, sex ratio, size range, migrational timing, spawning range, and spawn timing; and juvenile life history strategy, including smolt emigration timing. Emphasize spatial and temporal distribution relative to hatchery fish release locations and weir sites*

**- Identify the NMFS ESA-listed population(s) that will be directly affected by the program.** *(Includes listed fish used in supplementation programs or other programs that involve integration of a listed natural population. Identify the natural population targeted for integration).*

None.

**- Identify the NMFS ESA-listed population(s) that may be incidentally affected by the program.** *(Includes ESA-listed fish in target hatchery fish release, adult return, and broodstock collection areas).*

Populations of wild steelhead *Oncorhynchus mykiss* in the Columbia River Basin have declined dramatically from historical levels (Nehlsen et al. 1991; NRC 1996; Williams et



al. 1999). Average abundance of wild steelhead in the Yakima River Subbasin over the last two decades is only 2% of pre-1890 abundance levels reported by Howell et al. (1985). Causes of these declines include a host of environmental and human-induced factors (NRC 1996; Williams et al. 1999). In 1997 steelhead in the upper Columbia River were listed as endangered under the Endangered Species Act (ESA) and those in the Snake River were listed as threatened (62 FR 43937-43954). Stocks originating in mid-Columbia Basin tributaries (including the Yakima River) were listed as threatened in 1999 (64 FR 14517-14528). No hatchery fish have been released in the Yakima Subbasin since 1993. Regional plans recognize the need to protect and enhance weak upriver steelhead populations and their habitat while maintaining the genetic integrity of those stocks (NPPC 1994).

Steelhead in the Yakima Basin are divided into four populations: the Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River populations. The NOAA Interior Columbia Technical Recovery Team (ICTRT) identifies the Satus Creek population as steelhead that spawn in the Satus Creek drainage on the Yakama Indian Reservation, the mainstem Yakima River below Satus Creek, and tributaries to the lower mainstem. For management purposes, local planners have subdivided the Satus population into the Satus block, which spawns in the Satus Creek drainage, and a mainstem block, whose current and historic status is uncertain. The Toppenish population consists of steelhead that spawn in Toppenish Creek, its tributaries and the short stretch of the mainstem between Toppenish and Satus creeks, and is entirely on the Yakama Reservation. The Naches population includes steelhead spawning in the Naches River and its tributaries (including the Tieton, Little Naches, American, and Bumping rivers and Cowiche, Rattlesnake and Nile creeks), the mainstem Yakima from the Naches confluence to the Toppenish Creek confluence and the tributaries to that reach of the Yakima, including Ahtanum Creek. The Upper Yakima population consists of all steelhead that spawn in the Yakima River and its tributaries upstream of the Naches confluence. Together these four populations make up the Yakima MPG.

**2.2.2) Status of NMFS ESA-listed salmonid population(s) affected by the program.**

- **Describe the status of the listed natural population(s) relative to “critical” and “viable” population thresholds** (*see definitions in “Attachment I”*).
- **Provide the most recent 12 year (e.g. 1988-present) progeny-to-parent ratios, survival data by life-stage, or other measures of productivity for the listed population. Indicate the source of these data.**
- **Provide the most recent 12 year (e.g. 1988-1999) annual spawning abundance estimates, or any other abundance information. Indicate the source of these data.** (*Include estimates of juvenile habitat seeding relative to capacity or natural fish densities, if available*).
- **Provide the most recent 12 year (e.g. 1988-1999) estimates of annual**

**proportions of direct hatchery-origin and listed natural-origin fish on natural spawning grounds, if known.**

Adult and juvenile passage estimates for Yakima Basin projects are available at [www.ykfp.org](http://www.ykfp.org) and Columbia River [DART](#). Estimated counts of juvenile steelhead migrating past Prosser for recent years are:

Table 2.2.1. Prosser Dam Steelhead Juvenile (Downstream) Migration Estimates

Juv. Migr. Year	Wild	Hatch.	Total	%Wild
1988	42,522	14,636	57,158	74.4%
1989	22,345	5,056	27,401	81.5%
1990	21,805	6,499	28,304	77.0%
1991	21,309	612	21,921	97.2%
1992	33,096	549	33,645	98.4%
1993	17,165	3,109	20,274	84.7%
1994	17,977	602	18,579	96.8%
1995	17,765	16	17,781	99.9%
1996	43,366	14	43,380	100.0%
1997	44,631	0	44,631	100.0%
1998	85,360	0	85,360	100.0%
1999	38,266	0	38,266	100.0%
2000	42,696	0	42,696	100.0%
2001	28,428	0	28,428	100.0%
2002	38,560	0	38,560	100.0%
2003	29,641	0	29,641	100.0%
2004	32,428	0	32,428	100.0%
2005	46,741	0	46,741	100.0%
2006	18,838	0	18,838	100.0%
2007	31,898	0	31,898	100.0%
2008	26,327	0	26,327	100.0%
2009	28,754	0	28,754	100.0%
Average:	33,389	1,413	34,591	95.9%

Data source: YN databases (YakRSthdDB.xls)

<b>Table 2.2.2. Yakima Basin Adult Steelhead Escapement and Spawning Summary</b>						
<b>Run Year</b>	<b>Prosser Dam Count</b>	<b>Redd Counts by Survey Stream</b>				<b>Roza Dam Count</b>
		<b>Satus</b>	<b>Toppenish</b>	<b>Ahtanum</b>	<b>Naches</b>	
1987-88	2,840	445				
1988-89	1,162	404	45			
1989-90	814	289	26			
1990-91	834	125				
1991-92	2,263					116
1992-93*	1,184	73				15
1993-94	554	114				28
1994-95**	925	85				23
1995-96	505	148				92
1996-97*	1,106	76	5			22
1997-98*	1,113	190	13			51
1998-99	1,070	130	78			14
1999-00	1,611	169	185	11		14
2000-01	3,089	102	355	8		140
2001-02**	4,525	240	111	13		238
2002-03	2,235	172	354	8		134
2003-04	2,755	93	56	12	94	213
2004-05	3,451	108	99	16	140	227
2005-06**	2,005	60	20	1	19	117
2006-07	1,537	87	42**	4**	44	61
2007-08	3,310	110	68*	8*	11**	169
2008-09	3,450	119	79	3	29**	230

Blank = no data available

\* Partial survey.

\*\*Survey affected by access problems, high flows, or poor redd visibility

Hatchery releases were discontinued in the early 1990s. Recent 9-year average (since 1998-99 run year) escapement over Prosser Dam has been >98% wild; since 1983-84 the annual steelhead escapement has averaged about 92% wild. Data source: YN databases (YakRSthdDB.xls, [SthdReddSummary.doc](#)).

Available data indicates smolt-to-adult survival for naturally produced smolts in the Yakima Basin ranged from approximately 0.35% to 4.21% for calendar years 1985 through 2002 (C. Frederiksen, Yakama Nation Fisheries, personal communication).

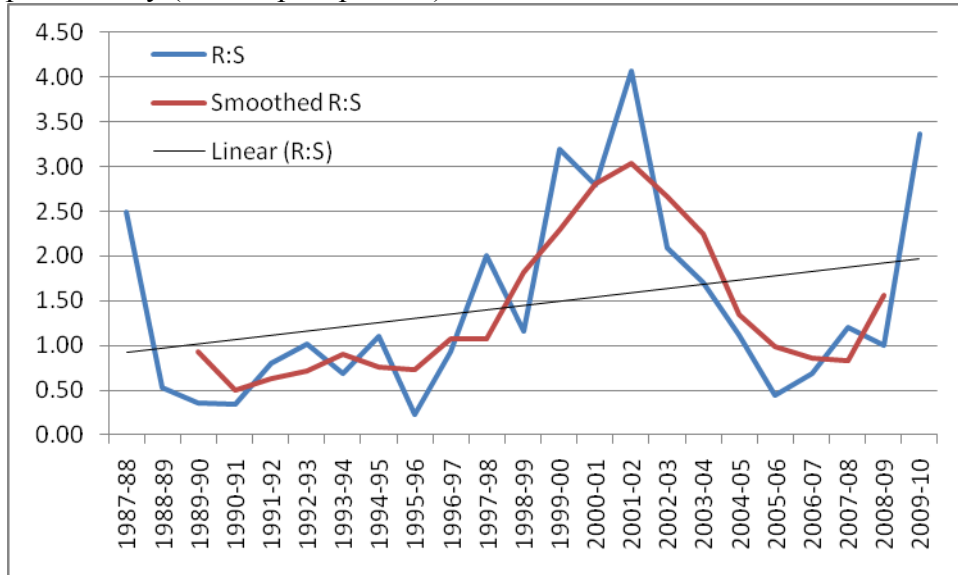
Table 2.2.3. Age-4 aggregate adult-to-adult productivity (returns per spawner) estimates for Yakima Basin Steelhead.

Run Year	Prosser Adult Count	Prosser Aggregate Age-4 Returns per Spawner	Smoothed Average Age-4 R:S
1983-84	1,140		
1984-85	2,194		
1985-86	2,235		
1986-87	2,465		
1987-88	2,840	2.49	
1988-89	1,162	0.53	
1989-90	814	0.36	0.93
1990-91	834	0.34	0.51
1991-92	2,263	0.80	0.63
1992-93	1,184	1.02	0.71
1993-94	554	0.68	0.90
1994-95	925	1.11	0.76
1995-96	505	0.22	0.74
1996-97	1,106	0.93	1.07
1997-98	1,113	2.01	1.08
1998-99	1,070	1.16	1.82
1999-00	1,611	3.19	2.29
2000-01	3,089	2.79	2.80
2001-02	4,525	4.07	3.03
2002-03	2,235	2.09	2.66
2003-04	2,755	1.71	2.25
2004-05	3,451	1.12	1.34
2005-06	2,005	0.44	0.99
2006-07	1,537	0.69	0.86
2007-08	3,310	1.20	0.83
2008-09	3,469	1.01	1.56
2009-10	6,743 <sup>1</sup>	3.36	
Mean	2,108	1.44	1.39
Geometric Mean	1,740	1.10	1.20

<sup>1</sup> through May 6, 2010.

Data source: YN databases (YakRStdDB.xls).

Figure 2.2.1. Graph of age-4 aggregate and smoothed average adult-to-adult productivity (returns per spawner) estimates for Yakima Basin Steelhead.



The data in Table 2.2.3 and Figure 2.2.1 are admittedly gross representations of adult-to-adult productivity. However, the geometric means for these metrics over a 26-year data set are greater than one and show an increasing trend. This indicates with high likelihood that combined artificial production and habitat restoration activities in the Yakima Basin are having a neutral or net positive impact on listed steelhead in the Basin.

Please see Yakima Basin steelhead HGMP (submitted to NOAA fisheries in 2005; available from YN) and [Yakima Basin steelhead recovery plan](#) for further information.

**2.2.3) Describe hatchery activities, including associated monitoring and evaluation and research programs, that may lead to the take of NMFS listed fish in the target area, and provide estimated annual levels of take (see “Attachment 1” for definition of “take”).**

**- Describe hatchery activities that may lead to the take of listed salmonid populations in the target area, including how, where, and when the takes may occur, the risk potential for their occurrence, and the likely effects of the take.**

*(e.g. “Broodstock collection directed at sockeye salmon has a “high” potential to take listed spring Chinook salmon, through migrational delay, capture, handling, and upstream release, during trap operation at Tumwater Falls Dam between July 1 and October 15. Trapping and handling devices and methods may lead to injury to listed fish through descaling, delayed migration and spawning, or delayed mortality as a result of injury or increased susceptibility to predation”).*

Upper Yakima Spring Chinook: Hatchery activities assessed include broodstock collection. M&E activities include: spawning ground surveys, juvenile PIT tagging of

un-PIT-tagged hatchery and wild/natural spring Chinook at Roza and Chandler, domestication selection research, NOAA Fisheries research, pathogen sampling, ecological interactions sampling, etc.

**- Provide information regarding past takes associated with the hatchery program, (if known) including numbers taken, and observed injury or mortality levels for listed fish.**

Please see Sections 12.5 through 12.12 and the summary take table in this HGMP.

**- Provide projected annual take levels for listed fish by life stage (juvenile and adult) quantified (to the extent feasible) by the type of take resulting from the hatchery program (e.g. capture, handling, tagging, injury, or lethal take).**

*Complete the appended “take table” (Table 1) for this purpose. Provide a range of potential take numbers to account for alternate or “worst case” scenarios.*

See the summary take table at end of this HGMP.

**- Indicate contingency plans for addressing situations where take levels within a given year have exceeded, or are projected to exceed, take levels described in this plan for the program.**

*(e.g. “The number of days that steelhead are trapped at Priest Rapids Dam will be reduced if the total mortality of handled fish is projected inseason to exceed the 1988-99 maximum observed level of 100 fish.”)*

Please see sections 12.5 through 12.12 of this HGMP. We do not anticipate exceeding take levels specified in this HGMP but if they do occur NMFS will be notified immediately. Contingency plans for YKFP projects are addressed by the YKFP Policy Group on a timely basis using adaptive management.

### **SECTION 3. RELATIONSHIP OF PROGRAM TO OTHER MANAGEMENT OBJECTIVES**

**3.1) Describe alignment of the hatchery program with any ESU-wide hatchery plan (e.g. Hood Canal Summer Chum Conservation Initiative) or other regionally accepted policies (e.g. the NPPC Annual Production Review Report and Recommendations - NPPC document 99-15). Explain any proposed deviations from the plan or policies.**

*(e.g. “The hatchery program will be operated consistent with the ESU-wide plan, with the exception of age class at release. Fish will be released as yearlings rather than as sub-yearlings as specified in the ESU-wide plan, to maximize smolt-to-adult survival rates given extremely low run sizes the past four years.”)*

The CESRF program and related M&E activities have been thoroughly reviewed by the ISRP through the NPCC project review process. It is the understanding of the YKFP that

all CESRF-related program activities are consistent with all applicable regional plans and recommendations.

A Yakima Subbasin salmon recovery plan is presently being developed in cooperation with the Yakima Subbasin Fish and Wildlife Recovery Board. A draft document (Freudenthal et al. 2005) is available for public review at <http://www.ybfwrb.org/Draft%20plan/RecPlanFinal.pdf>. Yakima Basin spring Chinook production activities will be consistent with this recovery plan. The program is included in the *United States versus Oregon* 2008-2017 Columbia River Fish Management Plan and the recently signed Columbia River Accords between the Columbia River Tribes and the Bonneville Power Administration.

**3.2) List all existing cooperative agreements, memoranda of understanding, memoranda of agreement, or other management plans or court orders under which program operates. Indicate whether this HGMP is consistent with these plans and commitments, and explain any discrepancies.**

Document Title	Type
Treaty of 1855. Asserted the right of the Yakama Nation to "take fish at all usual and accustomed fishing areas". Federal courts have held that this right means more than the right of Indians to hang a net in an empty river ( <i>Washington v Washington State Commercial Passenger Fishing Vessel Association, 1979</i> ).	Treaty
<i>United States versus Oregon</i> . 2008-2017 United States v. Oregon Management Agreement, May 2008. Appendix B of the original Columbia River Fish Management Plan stated a long-term goal (post-1990) of constructing a Yakima River Basin hatchery for the production of spring Chinook.	Federal Court Order
Northwest Power and Conservation Council (NPCC), Fish and Wildlife Program. The NPCC (formerly the Northwest Power Planning Council, NPPC) in 1982 first encouraged Bonneville Power Administration (BPA) to "fund the design, construction, operation, and maintenance of a hatchery to enhance the fishery for the Yakima Indian Nation as well as all other harvesters." Columbia River Basin Fish and Wildlife Program. Adopted November 15, 1982. The actual projects under which CESRF and habitat activities are conducted (and linked to the 2000 NPCC F&W Plan) are, of course, the M&E, O&M, and Mgmt, Data & Habitat projects recommended by Council and approved by BPA in the course of provincial review.	Federal law - Northwest Power Act
BPA. 1996. Yakima Fisheries Project. Final Environmental Impact Statement. Bonneville Power Administration. Washington Department of Fish and Wildlife. Yakama Indian Nation. January, 1996. DOE/EIS-0169. DOE/BP-2784. Portland, OR.	NEPA Environmental Impact Statement
Washington State RCW 77.95.210 (2) The Department shall not destroy hatchery origin salmon for the purposes of destroying viable eggs that would otherwise be useful for propagation or salmon recovery purposes, as determined by the department and Indian tribes with treaty fishing rights in a collaborative manner, for replenishing fish runs. July 2002.	Washington State Law
May 19, 1994 Memorandum of Understanding between the Confederated Tribes and Bands of the Yakama	MOU

Document Title	Type
Nation and the State of Washington regarding Planning, Construction and operation of the Yakima/Klickitat Fisheries Project.	
March 1998 Memorandum of Agreement between Bonneville Power Administration and USDOJ Bureau of Reclamation regarding Yakima Fisheries Project Water Rights.	MOA
September 7, 2000 Memorandum of Agreement (1425-00MA103000) between USDOJ Bureau of Reclamation and the Yakama Nation authorizing the Yakama Nation to Operate Fish Passage and Protection Facilities on BOR Property ( to the extent the facilities are used in association with supplementation research)	MOA
2008 Columbia Basin Fish Accords Memorandum of Agreement between the Three Treaty Tribes and FCRPS Action Agencies	MOA
WY-KAN-USH-MI WA-KISH-WIT	Columbia River Anadromous Fish Restoration Plan of the Columbia River Tribes. The Yakama Nation attempts to manage YKFP projects in a manner that is generally consistent with the principles outlined in this Plan.

See also 3.1.

### 3.3) Relationship to harvest objectives.

*Explain whether artificial production and harvest management have been integrated to provide as many benefits and as few biological risks as possible to the listed species. Reference any harvest plan that describes measures applied to integrate the program with harvest management.*

Higher rates of harvest can be maintained on populations that are more productive than populations that are less productive. If hatcheries are more productive (more adult recruits returning per adult taken into the hatchery) than natural environments (adults that spawn in the natural environment), then it can support a higher rate of harvest. Risks to less productive stocks (e.g., wild fish) can occur if they are harvested at rates that may be appropriate for more productive stocks. Spring Chinook returns (adults and jacks) to the Yakima River mouth since 2000 have averaged about 12,000 salmon annually (compared to a pre-supplementation average of fewer than 3,500 fish annually; Table 1.12.1), which has increased harvest opportunity both in and out of the Yakima River Basin. However, at this time it is difficult to assess how much of this improvement is due to natural factors such as improved freshwater and ocean conditions versus supplementation activities. Currently within the Yakima Basin, treaty reserved fisheries have harvested less than 12% of the returning adults on average annually since 1982 (Table 3.3.1). State recreational fishery regulations allow fishers to keep only marked (hatchery-origin) fish and regulations vary depending on run size and the proportion of hatchery-origin fish in the return.

Standard run reconstruction techniques are employed to derive reasonable estimates of harvest from the Columbia River mouth to the Yakima River mouth for spring Chinook. Data from databases maintained by the *United States versus Oregon* Technical Advisory Committee (TAC) are used to obtain harvest rate estimates for the aggregate spring Chinook population destined for tributaries above Bonneville Dam and to estimate



passage losses from Bonneville through McNary reservoirs. These data, combined with the Prosser Dam counts and estimated harvest below Prosser, are used to derive a Columbia River mouth run size estimate and Columbia River mainstem harvest estimate for Yakima spring Chinook (assuming Yakima spring Chinook are harvested in Columbia River fisheries at the same rate as all stocks destined for tributaries above Bonneville Dam). These data are being tracked and reported annually (Table 3.3.2).

Based on available CWT information, harvest managers have long assumed that Columbia River spring Chinook are not harvested in any abundance in marine fisheries as the timing of their ocean migration does not generally overlap either spatially or temporally with the occurrence of marine fisheries. The Regional Mark Information System (RMIS) is queried regularly for any CWT recoveries of CESRF releases in ocean or Columbia River mainstem fisheries. Based on the information reported to RMIS to date, it is believed that marine harvest accounts for about 0-2% of the total harvest of Yakima Basin spring Chinook.

Since 2001, tribal and recreational fisheries combined have harvested an average of about 660 CESRF and 940 wild/natural spring Chinook annually (Table 3.3.1). Also since 2001, in-basin harvest rates have averaged 11.7% on wild and 10.3% on CESRF fish, with tribal harvest rates averaging 8.9% and recreational harvest rates averaging 2.4% of the total Yakima Basin return of spring Chinook. Successful recreational fisheries for spring Chinook in the Yakima River are dependent on several conditions: a large number (preferably greater than 10,000) of returning spring Chinook, a return of wild/natural fish that does not far outnumber the return of hatchery fish, and favorable water conditions. This combination of conditions occurred in 2001, 2002, and 2004; recreational fisheries were precluded in other years.

**3.3.1) Describe fisheries benefiting from the program, and indicate harvest levels and rates for program-origin fish for the last twelve years (1988-99), if available. Also provide estimated future harvest rates on fish propagated by the program, and on listed fish that may be taken while harvesting program fish.**

#### **Yakima Basin Fisheries**

For spring fisheries in the Yakima River Basin, both the WDFW and the Yakama Nation employ two technicians and one biologist to monitor and evaluate in-basin harvest in the respective sport and tribal fisheries. Harvest monitoring consists of on-the-water surveys to collect catch data and to record CWT presence information for adipose-clipped fish. Survey data are expanded for time, area, and effort using standard methods to derive estimates of total in-basin harvest by fishery type (sport and tribal) and catch type (CESRF or wild denoted by adipose presence/absence).

**Table 3.3.1. Spring Chinook harvest in the Yakima River Basin, 1982-present.**

Year	Tribal		Non-Tribal		River Totals		Total	Harvest Rate <sup>1</sup>
	CESRF	Wild	CESRF	Wild	CESRF	Wild		
1982	0	434	0	0	0	434	434	23.8%
1983	0	84	0	0	0	84	84	5.8%
1984	0	289	0	0	0	289	289	10.9%
1985	0	865	0	0	0	865	865	19.0%
1986	0	1,340	0	0	0	1,340	1,340	14.2%
1987	0	517	0	0	0	517	517	11.6%
1988	0	444	0	0	0	444	444	10.5%
1989	0	747	0	0	0	747	747	15.2%
1990	0	663	0	0	0	663	663	15.2%
1991	0	32	0	0	0	32	32	1.1%
1992	0	345	0	0	0	345	345	7.5%
1993	0	129	0	0	0	129	129	3.3%
1994	0	25	0	0	0	25	25	1.9%
1995	0	79	0	0	0	79	79	11.9%
1996	0	475	0	0	0	475	475	14.9%
1997	0	575	0	0	0	575	575	18.1%
1998	0	188	0	0	0	188	188	9.9%
1999	0	604	0	0	0	604	604	21.7%
2000	53	2,305	0	100	53	2,405	2,458	12.9%
2001	572	2,034	1,252	772	1,825	2,806	4,630	19.9%
2002	1,373	1,207	492	36 <sup>2</sup>	1,865	1,243	3,108	20.6%
2003	134	306	0	0	134	306	440	6.3%
2004	289	712	569	109 <sup>2</sup>	858	820	1,679	11.0%
2005	46	428	0	0	46	428	474	5.4%
2006	246	354	0	0	246	354	600	9.5%
2007	123	156	0	0	123	156	279	6.5%
2008	521	414	586	11 <sup>2</sup>	1,107	426	1,532	17.8%
2009	1,089	715	463	8 <sup>2</sup>	1,552	722	2,275	18.8%
Mean	488	588	374	104	862	625	904	12.3%

1. Harvest rate is the total Yakima Basin harvest as a percentage of the Yakima River mouth run size.

2. Includes estimate of post-release mortality of unmarked fish.

### Columbia Basin Fisheries

Standard run reconstruction techniques are employed to derive estimates of harvest from the Columbia River mouth to the Yakima River mouth for spring Chinook. Data from databases maintained by the *United States versus Oregon* Technical Advisory Committee (TAC) are used to obtain harvest rate estimates downstream of the Yakima River for the aggregate Yakima River spring Chinook population and to estimate passage losses from Bonneville through McNary reservoirs. These data, combined with the Prosser Dam counts and estimated harvest below Prosser, are used to derive a Columbia River mouth run size estimate and Columbia River mainstem harvest estimate for Yakima spring Chinook.

**Table 3.3.2. Estimated run size, harvest, and harvest rates of Yakima Basin spring Chinook in Columbia River mainstem and terminal area fisheries, 1982-present.**

Year	Columbia R. Mouth Run Size	Col. R.	BON to	Yakima	Yakima	Columbia Basin			Col. Basin	
		Mouth to BON Harvest	McNary Harvest	R. Mouth Run Size	River Harvest	Total	Wild	CESRF	Total	Wild
1982	3,916	69	269	1,822	434	772	772	0	19.7%	
1983	2,493	120	100	1,441	84	304	304	0	12.2%	
1984	3,955	137	262	2,658	289	688	688	0	17.4%	
1985	5,275	193	180	4,560	865	1,238	1,238	0	23.5%	
1986	13,680	283	793	9,439	1,340	2,416	2,416	0	17.7%	
1987	6,348	99	383	4,443	517	1,000	1,000	0	15.7%	
1988	5,762	369	381	4,246	444	1,194	1,194	0	20.7%	
1989	9,031	217	679	4,914	747	1,642	1,642	0	18.2%	
1990	7,330	373	483	4,372	663	1,518	1,518	0	20.7%	
1991	4,686	186	283	2,906	32	501	501	0	10.7%	
1992	6,365	105	383	4,599	345	833	833	0	13.1%	
1993	5,261	45	320	3,919	129	494	494	0	9.4%	
1994	2,416	94	116	1,302	25	235	235	0	9.7%	
1995	1,392	1	69	666	79	149	149	0	10.7%	
1996	5,767	6	302	3,179	475	783	783	0	13.6%	
1997	5,179	3	348	3,173	575	926	926	0	17.9%	
1998	2,777	3	142	1,903	188	333	333	0	12.0%	
1999	3,992	4	184	2,781	604	792	792	0	19.8%	
2000	28,864	58	1,755	19,100	2,458	4,271	4,148	123	14.8%	
2001	30,661	976	3,818	23,265	4,630	9,424	5,417	4,008	30.7%	29.4%
2002	23,686	1,318	2,369	15,099	3,108	6,795	2,511	4,284	28.7%	24.4%
2003	9,652	307	728	6,957	440	1,475	873	601	15.3%	14.1%
2004	21,481	1,016	1,695	15,289	1,679	4,390	2,386	2,004	20.4%	15.6%
2005	11,998	337	692	8,758	474	1,503	1,175	328	12.5%	11.7%
2006	11,707	349	742	6,314	600	1,691	935	755	14.4%	12.6%
2007	5,103	217	333	4,303	279	829	380	449	16.3%	13.5%
2008	11,242	1,159	1,346	8,598	1,532	4,038	1,094	2,944	35.9%	25.1%
2009 <sup>1</sup>	13,372	1,069	1,035	12,120	2,275	4,378	1,234	3,144	32.7%	24.2%
Mean	9,407	325	721	6,505	904	1,950	1,285	2,058	18.0%	16.7%

1. Preliminary.

### Marine Fisheries

Based on available CWT information, harvest managers have long assumed that Columbia River spring Chinook are not harvested in any abundance in marine fisheries as the timing of their ocean migration does not generally overlap either spatially or temporally with the occurrence of marine fisheries (TAC 1997). The Regional Mark Information System (RMIS) will be queried regularly for any CWT recoveries of CESRF releases in ocean or Columbia River mainstem fisheries. Table 3.3.3 gives the results of a query of the RMIS database run on Feb. 12, 2010 for CESRF spring Chinook CWTs released in brood years 1997-2006. Based on the information reported to RMIS to date, it is believed that marine harvest accounts for about 0-2% of the total harvest of Yakima Basin spring Chinook.

**Table 3.3.3. Marine and freshwater recoveries of CWTs from brood year 1997-2006 releases of spring Chinook from the CESRF as reported to the Regional Mark Information System (RMIS) 12 Feb 2010.**

Brood Year	Observed CWT Recoveries			Expanded CWT Recoveries		
	Marine	Fresh	Marine %	Marine	Fresh	Marine %
1997	5	56	8.2%	8	321	2.4%
1998	2	53	3.6%	2	228	0.9%
1999		2	0.0%		9	0.0%
2000		14	0.0%		35	0.0%
2001		1	0.0%		1	0.0%
2002		7	0.0%		36	0.0%
2003		4	0.0%		10	0.0%
2004	1	139	0.7%	6	400	1.5%
2005 <sup>1</sup>		94	0.0%		94	0.0%
2006 <sup>1</sup>		9	0.0%		9	0.0%

1. Reporting of CWT recoveries to the RMIS database typically lags actual fisheries by one to two years. Therefore, CWT recovery data for brood years 2005-2006 are considered incomplete.

Data source for Tables 3.3.1-3.3.3: Bosch, 2009.

#### **3.4) Relationship to habitat protection and recovery strategies.**

*Describe the major factors affecting natural production (if known). Describe any habitat protection efforts, and expected natural production benefits over the short- and long-term. For Columbia Basin programs, use NPPC document 99-15, section II.C. as guidance in indicating program linkage with assumptions regarding habitat conditions.*

Limiting factors in the Yakima Subbasin and strategies to address them are well described in the Yakima Subbasin Plan (YSFWPB 2004). The following text is a summary of Yakima Basin limiting factors for aquatic habitats excerpted directly from the Subbasin Summary.

The loss of floodplain habitat, especially side channels and springs adjacent to the mainstem Naches and Yakima rivers, were identified as a significant limiting factor for the productivity of aquatic habitat in the subbasin. Actions to reverse this habitat loss are to relocate infrastructure (where possible) to allow natural processes to operate and reconnection of side channels by removal of obstructions. Artificial channels should be constructed where current conditions allow.

Riparian zone (the area adjacent to the river which is influenced by the river itself) problems include lack of shade and large woody debris (LWD), bank instability, and the inability of black cottonwood to reproduce under existing flow regimes. The Subbasin Plan calls for restoration of riparian zones and reduction of chronic bed instability through revegetation, introduction of LWD, protection of riparian areas by purchase or easement, improved riparian area management, and restoration of natural flow regime.

Channel confinement by levees, bridges and roads leads to altered floodplain functions and habitat loss. Multi-jurisdictional floodplain restoration and flood hazard reduction projects are necessary to reconnect floodplain side channels and to restore "unmanaged" or natural floodplain habitats.

The presence of reservoirs in the system has reduced peak flows and may have either increased or decreased energy available for sediment transport. The effect the natural glacial lakes had on flow and other attributes such as temperature is not well understood, and therefore we do not have accurate guides to pre-1850s conditions. Characterizations of the pre-1850s flow regimes are important for evaluation of how system function has changed, and how those changes have affected fish and wildlife populations. An objective is to find or create a new model to simulate the physical, chemical, thermal effects of lakes in the pre-1850s environment so that we can better understand the difference between current conditions and conditions that existed before the lakes were dammed.

Altered flows of water, sediment and water temperature changes (mostly summer increases) severely reduce the quantity and quality of aquatic habitats. The Plan contains objectives to replicate basin wide temperature variability by returning the timing and quantity of river flow to a more natural state. This restoration of a normative flow regime can be accomplished by the purchase, transfer, or lease of water rights; changes in flow management, conservation; and increased natural and artificial storage.

There is a high predation risk for juvenile salmonids in the Subbasin. To reduce the effect of elevated predation it is recommended to increase the number of spawning fish in the Yakima Subbasin, reduce populations of smallmouth bass in the lower Yakima River, improve cover and off channel habitats, and implement further control on predator populations in mainstem reservoirs.

Passage barriers and unscreened diversions and pumps have significant negative effects on salmon productivity. Related objectives of the plan are to improve passage and design of irrigation diversions to allow fish and sediment to pass through diversion points. The strategies recommended are to reduce or eliminate operational spill to tributaries during migration periods, increase irrigation efficiency, relocate or consolidate existing structures, replace or rebuild existing diversion dams, move or consolidate diversions, and provide pump screens to landowners.

Kachess, Kecheelus, Cle Elum and Bumping Dams block passage for sockeye and bull trout and Tieton Dam blocks passage for bull trout. A high priority objective is to restore passage to at least one dam by 2007, possibly through various fish passage options such as ladders, trap and haul, and modification of outlets for downstream passage.

Spring chinook populations have been dramatically reduced from pre-1850s

abundance levels. An important objective in the plan is to restore spring chinook population abundance, productivity and spatial distribution to viable, harvestable and sustainable levels over the next 30 years. This will require research on habitat restoration and population management activities such as harvest management and hatchery supplementation. Habitat improvements, especially side channel reconnection, should be concentrated in middle and lower alluvial floodplains.

As noted above, YKFP habitat actions to date have resulted in: the protection of almost 1,000 acres of prime floodplain habitat, reconnection and screening of over 15 miles of tributary habitat, substantial water savings through irrigation improvements, and restoration of over 80 acres of floodplain and side channels. Additional habitat improvements implemented by other entities, including the Conservation Districts, counties and private interests are also continuing in the basin.

To review the Yakima Subbasin Plan or for additional information, please refer to the Northwest Power and Conservation Council's website at:

<http://www.nwcouncil.org/fw/subbasinplanning/yakima/plan/>

or visit the Yakima Basin Fish and Wildlife Recovery Board's web site at:

<http://www.ybfwrb.org/>.

**3.5) Ecological interactions. [Please review Addendum A before completing this section. If it is necessary to complete Addendum A, then limit this section to NMFS jurisdictional species. Otherwise complete this section as is.]**

*Describe salmonid and non-salmonid fishes or other species that could (1) negatively impact program; (2) be negatively impacted by program; (3) positively impact program; and (4) be positively impacted by program. Give most attention to interactions between listed and "candidate" salmonids and program fish.*

Releases of large numbers of hatchery origin salmon have the potential to impact other species that are not the target of enhancement (non-target taxa; NTT). Impacts can occur through a variety of mechanisms such as competition, predation, and disease. We have planned and used a variety of techniques to manage risks to NTT including risk assessment, risk containment, risk reduction, and implementation of an impact detection plan.

Impacts to NTT are evaluated relative to baseline (pre-salmon supplementation) conditions and acceptable impacts for NTT that may manifest during the supplementation period were established as containment objectives for the YKFP (Pearsons et al. 1998; Table 3.5). When the status of a NTT exceeds acceptable levels, the YKFP policy group is notified, and risk containment measures are initiated under the adaptive management framework.

Table 3.5. Containment objectives for non-target taxa of concern (NTTOC) in the Yakima Basin relative to supplementing the upper Yakima stock of spring chinook salmon. Objectives refer to negative impacts upon one or more of a taxa's distribution, abundance or size structure relative to pre-supplementation levels.

NTTOC	Containment Objective
<b><i>Rare - species, stock, or regionally</i></b>	No impact
<ul style="list-style-type: none"> <li>Bull trout</li> <li>Pacific Lamprey</li> <li>Naches steelhead</li> <li>Satus steelhead</li> <li>Toppenish steelhead</li> <li>Upper Yakima steelhead</li> </ul>	Very low impact ( $\leq 5\%$ )
<b><i>Rare - in basin</i></b>	
<ul style="list-style-type: none"> <li>Marion Drain Fall chinook</li> <li>Mountain sucker</li> <li>Leopard dace</li> <li>Sand roller</li> </ul>	Low impact ( $\leq 10\%$ )
<b><i>Native game or food fish - very important</i></b>	
<ul style="list-style-type: none"> <li>Resident rainbow trout in the mainstem Yakima River</li> <li>Westslope cutthroat trout in the mainstem Yakima River</li> <li>Naches spring chinook salmon</li> <li>American River spring chinook salmon</li> </ul>	Moderate impact ( $\leq 40\%$ )
<b><i>Native game or food fish - important</i></b>	
<ul style="list-style-type: none"> <li>Mountain whitefish</li> <li>Resident rainbow trout in tributaries</li> <li>Westslope cutthroat trout in tributaries</li> </ul>	$\leq$ maximum impact that maintains all native species at sustainable levels
<b><i>Common</i></b>	
Other native species	

An evaluation of the impacts of spring Chinook salmon supplementation and coho salmon reintroduction (hereafter supplementation) to non-target fish taxa after eight years of stocking approximately one million yearling smolts annually in the upper Yakima

Basin between 1999 and 2006 are presented in Pearsons et al. (2007). Briefly, field methods included backpack electrofishing and snorkeling in tributaries, and drift-boat electrofishing in the mainstem. We used three sequential steps in our evaluation: First, we determined if spatial overlap occurred between supplementation fish and non-target taxa. Second, if overlap occurred, we determined if a change in abundance, size, or biomass occurred during supplementation. Lastly, if a change occurred we determined if the change could be reasonably attributed to supplementation. Spatial overlap and changes in abundance, size, or biomass were determined to be significant if they exceeded containment objectives. Salmon rarely overlapped cutthroat and bull trout in tributaries, but some overlap of cutthroat occurred in relatively high elevations of the mainstem, and considerable overlap with rainbow trout occurred in tributaries and the mainstem. Salmon overlapped mountain whitefish and sucker species in the mainstem, and dace and sculpin species in tributaries. With the exception of steelhead and mountain sucker, the lower 90% confidence limit of abundance, size, and biomass was above the containment objective for non-target taxa that overlapped significantly with salmon. We used rainbow trout as an analog for steelhead, and subadult suckers as an analog for mountain sucker. The lower 90% confidence limit of rainbow trout size in tributaries, and size and biomass in the mainstem, and the lower 90% confidence limit for mountain sucker abundance were below our containment objectives. Comparisons of rainbow trout size in tributaries, size and biomass in the mainstem, and mountain sucker abundance in mainstem sections with relatively high and low salmon abundance revealed that these change were unlikely to be the result of supplementation (BACIP  $P > 0.05$ ). Our data indicate that early stages of salmon supplementation have not impacted most valued species in the upper Yakima Basin beyond predetermined containment objectives, but the containment objective for steelhead abundance in the Teanaway Watershed has been exceeded.

We used a Before-After-Control-Impact-Paired design to evaluate impacts of hatchery salmon reintroduction and supplementation on rainbow trout *Oncorhynchus mykiss* in two contiguous rivers (North Fork and mainstem Teanaway River; Pearsons and Temple 2007). Trout and salmon were sampled with backpack electrofishers and abundance, size, and biomass was estimated in treatment and control sites before (1990-1998) and during hatchery releases (1999-2006). We detected statistically significant impacts to rainbow trout abundance and biomass ( $P < 0.05$ ), but not size ( $P > 0.05$ ) from production scale releases of coho salmon *O. kisutch* (1999) and spring Chinook salmon *O. tshawytscha* (2000-2006) in the Teanaway Basin. Impacts were largest in the stream closest to the release site (North Fork Teanaway River). The impacts to rainbow trout were likely the result of cumulative impacts from hatchery released Chinook salmon smolts, residualized spring Chinook salmon, and an increase in naturally produced parr. Each one of these life-stages was significantly correlated with differences in trout abundance in at least one treatment location ( $P < 0.05$ ). We also observed that the combined biomass of rearing rainbow trout and spring Chinook salmon was reduced by supplementing spring Chinook salmon ( $P < 0.05$ ). However, these differences are based on observations from sampled control and treatment reaches and may not reflect the Teanaway system as a whole. This study highlights the importance of evaluating hatchery programs from a long-term, holistic, and multi-species perspective.



Current evaluations have identified that smallmouth bass, northern pikeminnow, and piscivorous birds are consuming large numbers of salmonids. For example, smallmouth bass in the lower Yakima River consumed an average of 188,058 salmonids each year from March 22 to June 16, 1998 to 2002, and of these, only 2,873 were yearling salmonids (primarily spring Chinook salmon). From 1999 to 2002, smallmouth bass predation on all yearling salmonids never exceeded 0.6% of the annual production of hatchery and wild fish combined. Estimated smallmouth bass consumption of hatchery ocean-type (fall-run) Chinook salmon has only comprised up to 4% of the annual production of these fish. The diet of northern pikeminnow is comprised of a high proportion of salmonids, including yearlings. In river estimates have put the population of NPM at 142-516 fish per mile. The abundance and consumption rate of northern pikeminnow suggests that predation on smolts may be significant. Channel catfish have also been captured with salmonids in their gut. Unfortunately, calculating an abundance estimate for channel catfish and northern pikeminnow has been challenging. This has resulted in an inability to estimate the number of salmonids consumed by catfish. Common mergansers, American white pelicans, double-crested cormorants and gulls are great enough in abundance and bioenergetic capacity to consume large numbers of salmonids. Mergansers were the most significant predator in the upper river, potentially consuming 35% of the hatchery spring chinook and 32% of the hatchery coho. However an earlier dietary analysis of Yakima River mergansers found they eat a broad range of small fish with salmonids only becoming common in their diet during fall/winter. Mergansers have not shown a numeric response to increases in the number of spring Chinook smolts in the Yakima River over the last 9 years.

Pelicans, which inhabit the lower and middle Yakima River, could potentially consume the entire hatchery production of salmon smolts of all species in the lower river, yet only supply 26% of their dietary requirements. Pelican numbers in the Yakima Basin have declined to 17.5 birds per day from 57 birds in 2005, with cormorant numbers increasing. Based on bioenergetic and behavioral models, Chandler pelicans and Horn Rapids gulls could potentially consume up to 10% of the total Yakima Basin hatchery production of salmon smolts of all species. However, pelicans feeding at Chandler Fish Bypass often capture fish that are substantially larger than spring Chinook smolts, including adult chiselmouth, sucker, and pikeminnow. Correlation analysis suggest that pelicans and gulls at Chandler Fish Bypass and Horn Rapids Dam are not responding to passage of spring chinook smolts, but may be tracking the passage of coho smolts, which are larger in size and may be a more efficient food source. PIT tags found at bird congregation sites, including Chandler, suggest that greater numbers of coho smolts are consumed than spring and fall Chinook.

The higher the river volume during peak smolt out-migration, the lower the predation rate by birds. Fish exiting Chandler Bypass are vulnerable to bird predation at low river flows, while being largely secure from bird predation at high flows. With the exception of gulls at Horn Rapids in 2006, the number of salmon smolts consumed by birds at Horn Rapids Dam and Chandler has declined each year since 2002. Examining a greater number of stomach contents of American white pelicans and double-crested cormorants

from the Yakima River would help us estimate the number of salmonids consumed by birds in the Yakima Basin.

Density dependent relationships between Chinook salmon abundance and growth and survival exist in the upper Yakima Basin. Larger numbers of fall parr are correlated with smaller size. An asymptotic relationship exists between parent abundance and a fall parr abundance index. Competition indices suggest that competition for food is stronger than competition for space. However, the amount of space and food available to juvenile salmon may be strongly influenced by artificially high summer flows. Unless the capacity of the environment increases (e.g., altered stream flows, increased passage), the natural production benefits of supplementation will be largely confined to years when natural origin fish escapement is below the carrying capacity of the environment.

## **SECTION 4. 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.**

*For integrated programs, identify any differences between hatchery water and source, and “natal” water used by the naturally spawning population. Also, describe any methods applied in the hatchery that affect water temperature regimes or quality. Include information on water withdrawal permits, National Pollutant Discharge Elimination System (NPDES) permits, and compliance with NMFS screening criteria.*

The process water is pumped from a river pump station having an initial capacity of 14,640 gpm and a wellfield of six wells having a pumping capacity of 7,335 gallons per minute (gpm). Process water is available to supply the Cle Elum Supplementation and Research Facility year-round. All process water demands within the hatchery incubation building are supplied by water from the wellfield. The rest of the hatchery process water demands (raceways and adult holding ponds) are supplied by either wellfield or river water or a combination of these water supplies. The schedule of hatchery water needs is partly based on available water temperatures since it is preferable to use cool water rather than warm water during the summer months. As river water temperature increases, more well water is required to lower the temperature of the blended water.

The size and capacity of the six well pump stations and the river pump meet the varying demand of the hatchery facilities. Raw water from the wells or river is passed through degassing columns to increase dissolved oxygen and remove supersaturated nitrogen gas. This process water is then piped to the various hatcheries facilities. Process well water is exclusively used to meet all hatchery building demands. The other hatchery facilities receive process water from either the river pump station or the wellfield. The source for the raw water is dictated by the river water temperatures and usage.

Please see Cle Elum Hatchery Operations and Procedures Manual, Part 2, Chapter 4 (attached to this HGMP as a pdf) for a complete description of water operations at the Cle Elum main facility and acclimation sites.

**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.**

*(e.g. "Hatchery intake screens conform with NMFS screening guidelines to minimize the risk of entrainment of juvenile listed fish.").*

The facility operates within the limitations established in its National Pollution Discharge Elimination System (NPDES) permit. Hatchery and acclimation site in-take screens meet all relevant criteria. To date, no listed fish have been observed inside the hatchery grounds.

## **SECTION 5. FACILITIES**

*Provide descriptions of the hatchery facilities that are to be included in this plan (see "Guidelines for Providing Responses" Item E), including dimensions of trapping, holding incubation, and rearing facilities. Indicate the fish life stage held or reared in each. Also describe any instance where operation of the hatchery facilities, or new construction, results in destruction or adverse modification of critical habitat designated for listed salmonid species.*

### **5.1) Broodstock collection facilities (or methods).**

Returning adult spring Chinook are monitored at the Roza adult monitoring facility located on the Yakima River (Rkm 205.8). This facility provides the means to monitor every fish returning to the upper Yakima Basin and to collect adults for the CESRF program. All returning CESRF fish (adipose-clipped fish) are sampled for biological characteristics and marks and returned to the river with the exception of fish collected for experimental sampling and hatchery control line broodstock. Until 2007, all wild/natural fish passing through the Roza adult monitoring facility are returned directly to the river with the exception of fish collected for broodstock or fish with a metal tag detection which are sampled for marks and biological characteristics. Beginning in 2007, the project is attempting to DNA sample every spring Chinook passing upstream through the Roza adult monitoring facility for a long-term parent-progeny pedigree analysis. Due to logistical constraints at the facility this may not be possible in all years.

Adult Steelhead run timing at Roza is generally February through early May with fewer than 25 steelhead generally observed during adult spring Chinook operations at Roza (mid-April through September). These steelhead are sampled for marks and biological data prior to returning them to the river. Additional detail regarding the handling of adult steelhead at Roza is described in attachments to the steelhead HGMP.

**5.2) Fish transportation equipment (description of pen, tank truck, or container used).**

IHOT guidelines for transportation are followed.

Equipment Type	Capacity (gallons)	Supplemental Oxygen (y/n)	Temperature Control (y/n)	Normal Transit Time (minutes)	Chemical(s) Used	Dosage (ppm)
Adult Transfer Tanker Truck	700	Y	N	60	Light dose MS	
Juvenile Transfer Tanker Truck	2500	Y	N	40		

**5.3) Broodstock holding and spawning facilities.**

The CESRF is located on the Yakima River just south of the town of Cle Elum (rkm 295.5). It is used for adult broodstock holding and spawning, and early life incubation and rearing. Fish are spawned in September and October of a given brood year (BY).

Integrated Hatchery Operations Team (IHOT) adult holding guidelines followed for adult holding, density, water quality, alarm systems and predator control measures to provide the necessary security for the broodstock.

Ponds (number)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Available Flow (gpm)
2	Upwelling Inlet Pond	10400	102	15	6.8	1100

**5.4) Incubation facilities.**

Incubator Type	Units (number)	Flow (gpm)	Volume (cu.ft.)	Loading-Eyeing (eggs/unit)	Loading-Hatching (eggs/unit)
Iso-Bucket/Troughs (28 iso buckets/trough)	336	0.3/Iso-Bucket	2 gal/square buckets	3500	nya
Vertical Stack Trays (24 stacks with 16 trays/stack)	384	4/stack	nya	nya	5000

**5.5) Rearing facilities.**

Ponds (number)	Pond Type	Volume (cu.ft)	Length (ft.)	Width (ft.)	Depth (ft.)	Flow (gpm)	Maximum Flow Index	Maximum Density Index
18	Raceways-Flow Through (Cle Elum Hatchery)	3500	100	10	3.5	650	0.125 lbs/cf/inc	0.75 lbs/cf
18	6	5400	100	12	4.5	650	0.110	0.66

	Raceways (Flow Through) Per Acclimation Site (Easton, Clark Flats, & Jack Pine)							
--	--	--	--	--	--	--	--	--

**5.6) Acclimation/release facilities.**

Acclimation sites are located at Easton, Jack Creek (N. Fork Teanaway River), and Clark Flat (see section 1.5 for exact location descriptions). Each acclimation site includes a river intake, six raceways, a cleaning waste basin, service building with office and storage, generators for primary or backup power, and a computerized system to monitor physical processes such as water flows and temperatures. The acclimation sites are the final step in rearing young fish. Fish are transferred to the acclimation sites at approximately 1.25 years of age, when they are about 11 centimeters in length and average about 28-32 fish per pound. Fish spend about 6-12 weeks at the acclimation sites and the purpose is to have the fish imprint to the local water, adjust to the local environment, and continue their growth prior to release to the wild. Smolts are allowed to migrate volitionally beginning on or about March 15. The channel through which the fish migrate from the acclimation site raceways to the river are equipped with PIT tag detectors and acclimation site exit PIT detections are automatically uploaded to PTAGIS through computer systems maintained at each site by the Pacific States Marine Fisheries Commission.

**5.7) Describe operational difficulties or disasters that led to significant fish mortality.**

The Yakima Basin experienced a presumably natural high incidence of BKD in 2001. Roughly 50% of 2001 BY females tested with BKD therefore, the release for BY 2001 did not meet the project’s release goal of 810,000 smolts. In release years 2000 and 2006, the Jack Creek acclimation site experienced problems due to excessive winter conditions (frozen pipes inhibiting water flow) which resulted in the loss of 20,000 (release year 2000) to 45,000 (release year 2006) fish. The YKFP policy group is considering options (e.g., moving fish to this acclimation site later in the winter) for resolving these problems.

Otherwise, no significant fish mortality has occurred.

**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.**

*(e.g. “The hatchery will be staffed full-time, and equipped with a low-water alarm system to help prevent catastrophic fish loss resulting from water system*

*failure.”).*

The CESRF was designed with state-of-the-art monitoring and alarm systems. Backup generators are in place to maintain water delivery to adult holding, egg incubation, and juvenile rearing at the main facility and acclimation sites. The facility is sited so as to minimize the risk of catastrophic fish loss from flooding. Staff are notified immediately by alarm systems of emergency situations at the facility. The facility is continuously staffed to assure the security of fish stocks on-site. All permanent staff live on-site.

## **SECTION 6. 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 wild fish of the same species/population.**

### **6.1) Source.**

*List all historical sources of broodstock for the program. Be specific (e.g., natural spawners from Bear Creek, fish returning to the Loon Creek Hatchery trap, etc.).*

The broodstock chosen represents natural populations native to the watersheds in which hatchery fish will be released. Broodstock for the program are selected from naturally produced Chinook acquired at Roza adult monitoring facility and are destined for spawning grounds in the upper Yakima basin.

### **6.2) Supporting information.**

#### **6.2.1) History.**

*Provide a brief narrative history of the broodstock sources. For listed natural populations, specify its status relative to critical and viable population thresholds (use section 2.2.2 if appropriate). For existing hatchery stocks, include information on how and when they were founded, sources of broodstock since founding, and any purposeful or inadvertent selection applied that changed characteristics of the founding broodstock.*

Broodstock Source	Origin	Year(s) Used	
		Begin	End
Yakima Spring Chinook	N	1997	

See 1.11.1.

#### **6.2.2) Annual size.**

*Provide estimates of the proportion of the natural population that will be collected for broodstock. Specify number of each sex, or total number and sex ratio, if known. For broodstocks originating from natural populations, explain how their use will affect their population status relative to critical and viable thresholds.*

See 1.11.1.

**6.2.3) Past and proposed level of natural fish in broodstock.**

*If using an existing hatchery stock, include specific information on how many natural fish were incorporated into the broodstock annually.*

See 1.11.1. In general, approximately 600 to 700 spring Chinook are collected annually at Roza Dam to fulfill program broodstock and research requirements.

**6.2.4) Genetic or ecological differences.**

*Describe any known genotypic, phenotypic, or behavioral differences between current or proposed hatchery stocks and natural stocks in the target area.*

Broodstock for the program are selected from naturally produced Chinook acquired at Roza Dam facility and are destined for spawning grounds in the upper Yakima basin.

Most demographic variables are similar between natural and hatchery origin fish. However, preliminary results indicate that hatchery origin fish are returning at smaller size-at-age and may be less successful at producing progeny in the wild than their wild/natural counterparts. In addition, hatchery fish have lower fecundity and are maturing 5 days earlier on average at CESRF. Long-term fitness of the target population is being evaluated by a large-scale test of domestication. Semi-natural rearing and predator avoidance training have not resulted in significant increases in survival of hatchery fish, however growth manipulations in the hatchery may be reducing the number of precocious males produced by the CESRF and increasing the number of migrants. Ecological impacts to valued non-target taxa from supplementation activities have remained within containment objectives. For detailed information describing YKFP genetics and ecological interactions studies, please refer to the “Reproductive Ecology and Success”, “Ecological Interactions Team Reports and Publications”, and “Genetics” report links listed under the “Technical Reports and Publications” link on the [www.ykfp.org](http://www.ykfp.org) web site.

**6.2.5) Reasons for choosing.**

*Describe any special traits or characteristics for which broodstock was selected.*

The broodstock chosen does not have a history of pathogens endemic to the watershed. The broodstock chosen has the desired life history traits to meet harvest goals.

Broodstock for the program are selected from naturally produced Chinook that have life history traits that meet overall project goals.

**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.**

*(e.g. “The risk of among population genetic diversity loss will be reduced by selecting the indigenous Chinook salmon population for use as broodstock in the supplementation program.”).*

Originally the project intended to manage the proportion of natural- to hatchery-origin adults allowed to spawn naturally. However, we have concluded that actively managing for a specific spawning escapement proportion (natural- to hatchery-origin adults) is infeasible or undesirable. A number of factors went into this decision: the political climate regarding surplusing of fish, conflicts with overall production goals of the project, our inability to find clear guidance from the literature equating percentage of hatchery fish on the spawning grounds with fitness loss, considerations about what risk is acceptable in a project designed to evaluate impacts from that risk, and finally, the numerous risk containment measures already in place in the project. These measures include:

- random, representative broodstock selection
- local broodstock
- use of natural broodstock
- factorial mating to maintain diversity
- low rearing densities
- underwater feeders and cover to encourage natural behavior
- intensive disease monitoring
- acclimation sites to increase in-river distribution
- state-of-the-art marking strategies for M&E
- test different rearing/release strategies to increase survival
- intensive monitoring and evaluation over an historical timeline of ecological interactions, adult return composition (hatchery- and natural-origin, sex, age, length, weight, etc.), spawning distribution, straying, comparison with a wild control population, etc. See Appendix A of this HGMP.

Monitoring and Evaluation results from the project are reviewed annually at both internal and public project reviews. The project managers are committed to adaptive management and project strategies and parameters are adjusted based on technical recommendations resulting from the annual reviews.

See also 1.11, 1.12, Busack et al. 1997, and Knudsen et al. 2006.

## **SECTION 7. BROODSTOCK COLLECTION**

### **7.1) Life-history stage to be collected (adults, eggs, or juveniles).**

Returning age-3, age-4, and age-5 fish are collected randomly at Roza Dam for CESRF broodstock according to protocols described throughout this HGMP.

### **7.2) Collection or sampling design.**

*Include information on the location, time, and method of capture (e.g. weir trap, beach seine, etc.) Describe capture efficiency and measures to reduce sources of bias that could lead to a non-representative sample of the desired broodstock source.*



See 1.11.1.

**7.3) Identity.**

*Describe method for identifying (a) target population if more than one population may be present; and (b) hatchery origin fish from naturally spawned fish.*

Marking techniques are used to distinguish among hatchery population segments with 100% of the hatchery fish released being marked so that they can be distinguished from the natural population. The marked fish can be identified using non-lethal means. Natural-origin fish make up 100% of the broodstock for this program.

The CESRF program has used adipose fin-clips, coded-wire tags (CWT), passive integrated transponder (PIT) tags, and visual-implant elastomer (VIE) tags in combination for monitoring and evaluation purposes. Marking schemes by brood year are available from the Yakama Nation and are also submitted electronically to the regional PTAGIS (PIT) and RMPC (CWT) web sites and to BPA in annual reports.

**7.4) Proposed number to be collected:**

**7.4.1) Program goal (assuming 1:1 sex ratio for adults):**

In general, approximately 600 to 700 spring Chinook are collected annually at Roza Dam to fulfill program broodstock and research requirements. See also 1.11 and 1.12.

**7.4.2) Broodstock collection levels for the last twelve years (e.g. 1988-99), or for most recent years available:**

See 1.11.1.

Data source: (“Broodstock Collection and Representation” in “Summary of Data Collected by the Yakama Nation relative to Yakima River Spring Chinook Salmon and the Cle Elum Spring Chinook Supplementation and Research Facility”, Appendix in BPA annual reports).

**7.5) Disposition of hatchery-origin fish collected in surplus of broodstock needs.**

*Describe procedures for remaining within programmed broodstock collection or allowable upstream hatchery fish escapement levels, including culling.*

Excess adults are culled at random and either released back to the river or donated to Yakama Nation depending on their quality.

**7.6) Fish transportation and holding methods.**

*Describe procedures for the transportation (if necessary) and holding of fish, especially if captured unripe or as juveniles. Include length of time in transit and care before and during transit and holding, including application of anesthetics, salves, and antibiotics.*

See 5.2 and 5.3. Broodstock are collected at Roza Dam, transported to the CESRF, and held in a manner that results in an average of about 12% prespawning mortality annually (Table 9.1.1).

**7.7) Describe fish health maintenance and sanitation procedures applied.**

[Integrated Hatchery Operations Team](#) (IHOT 1995), [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. Fish transfers into the subbasin are inspected and accompanied by notifications as described in these guidelines.

Adults used for spawning and their progeny are tested for a variety of pathogens accepted as important in salmonid culture (USFWS Inspection Manual, 2003), on a population or "lot" basis. At the CESRF, and in the Columbia Basin it has been accepted that the most significant fish pathogen for spring Chinook is *Renibacterium salmoninarum*, the causative agent of Bacterial Kidney Disease (BKD). All adult females and 60 juveniles from each acclimation pond are individually tested for levels of *Renibacterium salmoninarum* using ELISA (Enzyme linked Immuno-sorbant Assay). ELISA data are reported annually to CESRF and YKFP staff for management purposes, eventual data entry and comparisons of ponds and rearing parameters. To date, no significant occurrences of other pathogens have been observed. Periodic field exams for external parasites and any signs of disease are performed on an "as needed" basis. Facility staff have been trained to recognize early signs of behavior changes or diseases and would report any abnormalities to the USFWS, Olympia Fish Health Center for further diagnostic work.

Adult females are ranked from 0 to 13 based on the relative amounts of BKD in the tissue samples of the tested fish. All BKD ranks below 5 are considered low risk for transferring significant BKD organisms through the egg to cause significant disease in progeny receiving proper care. The progeny of adults with BKD rank 6 are considered to be moderate risk and those with BKD rank 7 or greater are considered to be high risk. Given these data, the CESRF chose to rear only the progeny of females with a BKD rank of 6 or less through brood year 2001. Beginning with brood year 2002, the progeny of fish with BKD rank 6 (moderate risk) or greater (high risk) have not been used for production purposes at the CESRF.

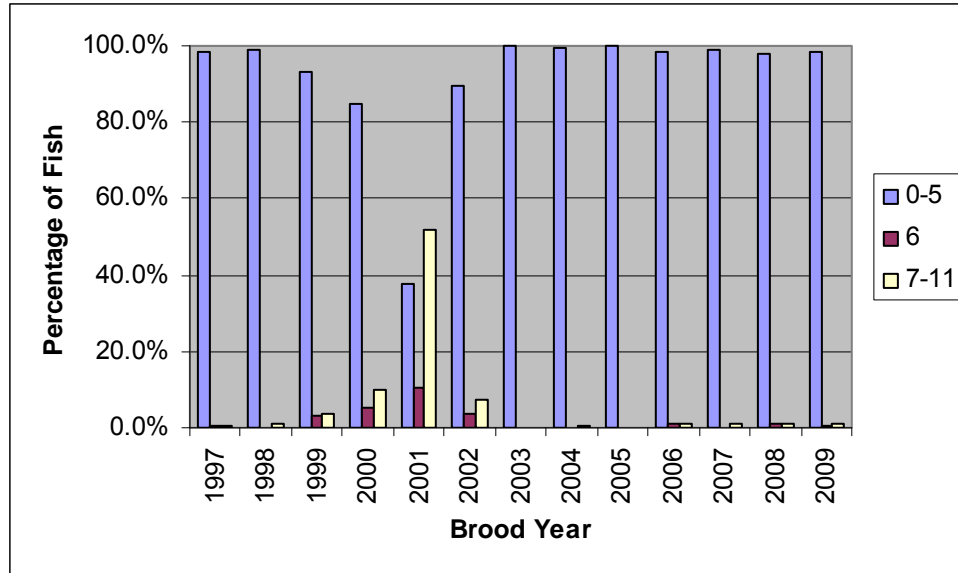


Figure 7.7. Proportion of wild/natural females spawned at CESRF by BKD rank, 1997 – present.

**7.8) Disposition of carcasses.**

*Include information for spawned and unspawned carcasses, sale or other disposal methods, and use for stream reseedling.*

At spawn time, carcasses are bagged and frozen. In early winter (November-December), these frozen carcasses are trucked and planted in main spawning areas within the upper Yakima subbasin (known from annual comprehensive spawner surveys) to provide ecological benefits. Prior to 2009, spring Chinook from the CESRF were considered to be low risk for disease transfer and carcasses from spawning operations were distributed without treatment. In 2009, a low level of IHN was detected in the adult holding ponds and no carcasses were distributed for this brood. Beginning in 2010, all carcasses will be treated prior to distribution. Following USFWS protocol, hatchery carcasses will be eviscerated, heads removed, and heated at 100° F for three hours, then frozen. This process effectively kills any viruses or pathogens potentially hosted by these fish.

**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.**

*(e.g. “The risk of fish disease amplification will be minimized by following Co-manager Fish Health Policy sanitation and fish health maintenance and monitoring guidelines”).*

See 6.3.

**SECTION 8. MATING**

**Describe fish mating procedures that will be used, including those applied to meet performance indicators identified previously.**

### **8.1) Selection method.**

*Specify how spawners are chosen (e.g. randomly over whole run, randomly from ripe fish on a certain day, selectively chosen, or prioritized based on hatchery or natural origin).*

Males and females available on a given day are mated randomly. Spawning protocols for mating are set at a 3x3 factorial (Busack and Knudsen 2007), and 2x2 factorial if a limited number of fish only are available. The exception to this rule is the Spawning Channel Research Project that allows fish to select their own mates.

### **8.2) Males.**

*Specify expected use of backup males, precocious males (jacks), and repeat spawners.*

Jacks (age 3 males) are currently used in proportion to their representation in the natural population on a broodyear basis. During the initial 2 years of operation, jacks were used in proportion to their contribution to that year's adult run. Back-up males are used very rarely in the spawning protocol.

### **8.3) Fertilization.**

*Describe spawning protocols applied, including the fertilization scheme used (such as equal sex ratios and 1:1 individual matings; equal sex ratios and pooled gametes; or factorial matings). Explain any fish health and sanitation procedures used for disease prevention.*

Broodstock are held until they reach maturity on a schedule similar to wild fish, with spawning from early September into October. Mature fish are taken from the adult holding area, identified by PIT tags, photographed, and spawned. Eggs and sperm (milt) from individual spawners are placed in separate containers.

Mating is randomized with respect to phenotypic traits, including size, within each group of adults that are ripe on the day of spawning. A factorial mating scheme is used with each female's eggs divided into several lots. Each lot is fertilized with the sperm from a different male. After fertilization, the egg lots are combined for incubation. On many spawning days mature females outnumber mature males 2:1 requiring that males be used in two sets of 3♀ x 3♂ factorials resulting in an actual 6♀ x 3♂ factorial design. Each female's eggs are later divided into two equal lots for experimental treatment and control groups.

### **8.4) Cryopreserved gametes.**

*If used, describe number of donors, year of collection, number of times donors were used in the past, and expected and observed viability.*

The project collected and cryopreserved gametes in 2001 and 2002 for storage at WSU at the Nez Perce Gene Bank Facility. Below are pertinent sections of chapter 3 from the [2003 genetics annual report](#).

All cryogenic activities were carried out in the walk-in refrigerator at the Cle Elum Supplementation and Research Facility (CESRF). Labeled bags of surplus semen were carried in from the fertilization room, mixed 1:3 with extender and vacuum-pumped from a bubbler into plastic 0.5 ml straws, which were then sealed with latex powder. Typically we filled 40 straws/male, less if less semen was available. For the most part we used the DMSO-glucose-egg yolk extender described by Wheeler and Thorgaard (1991), but in 2002 we also used the extender of Erdahl (1982). Straws were placed in groups of 5 into plastic goblets, which were clipped into pairs onto metal canes. Canes were laid on a rack over liquid nitrogen for initial freezing for at least 10 min. After freezing, the canes were placed into canisters and immersed in liquid nitrogen in a large Dewar cryo flask. Bubbler, pump, straws, sealing powder and canes were all obtained from IMV International (Maple Grove, MN).

Samples were stored in the walk-in freezer at CESRF, with nitrogen being added as required. Samples were transported in the Dewar flask to Washington State University, where they were placed in long-term storage in the BPA-funded Nez Perce Gene Bank facility in Heald Hall.

Table 8.4.1 presents the males used, dates spawned, and amount of material cryopreserved per male. Fifty-seven males were sampled in 2001, and 91 males were sampled in 2002. These numbers represent 32% of the males spawned in 2001 and 53% of the males spawned in 2002. Table 8.4.1 also shows the distribution of cryopreservation effort over the course of the spawning season. In 2001 we did cryopreservation on only two days, in the middle of the season, but achieved a high sampling rate on those two days. In contrast, in 2002, we did cryopreservation on five days that fairly well spanned the spawning season. In addition, on the days we did cryopreservation we sampled all or nearly all the males spawned, so the samples are a good representation of the 2002 male spawning population.

Table 8.4.1. Males sampled for cryopreservation 2001-2002 compared to total males spawned

	Spawn Date	Males Spawned	Males Cryopreserved	Percentage Cryopreserved
2001				
	09/04/2001	18		0%
	09/10/2001	25		0%
	09/12/2001	13		0%
	09/17/2001	29	24	83%
	09/19/2001	10		0%
	09/24/2001	52	33	63%
	01/01/2001	26		0%
	10/08/2001	3		0%
2002				
	09/04/2002	3		0%
	09/10/2002	6	6	100%
	09/11/2002	12		0%
	09/17/2002	21	16	76%
	09/19/2002	10		0%
	09/24/2002	35	32	91%
	09/25/2002	34		0%
	10/01/2002	32	24	75%
	10/08/2002	17	13	76%

**8.5) 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.**

*(e.g. “A factorial mating scheme will be applied to reduce the risk of loss of within population genetic diversity for the small chum salmon population that is the subject of this supplementation program”).*

See 6.3.

**SECTION 9. INCUBATION AND REARING -**

**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) Incubation:**

**9.1.1) Number of eggs taken and survival rates to eye-up and/or ponding.**

*Provide data for the most recent twelve years (1988-99), or for years dependable data are available.*

As described earlier, a portion of natural- and hatchery-origin (NoR and HoR, respectively) returning adults are captured at Roza Dam during the adult migration and taken to the CESRF for broodstock and/or research purposes. Fish are held in adult

holding ponds at the CESRF from capture in the spring and summer until spawning in September through early October. All mortalities during the holding period are documented by sex. During the spawning period data are kept on the number of males and females of each origin used for spawning or other purposes. All females have samples taken that are later evaluated for presence of BKD-causative agents. Eggs from females with high BKD-presence indicators are generally excluded (see Female BKD Profiles). Once fertilized, eggs are placed in holding troughs until shock time. Dead eggs are then sorted and hand-counted. All live eggs are machine counted, sorted into two lots per female (treatment and control) and placed into incubation (heath) trays. Using hand counts of egg samples from a subsample of female egg lots, WDFW staff determined that machine counts are biased and that the best approximation of live egg counts is given by the following equation:

$$\left( \left( \frac{\text{no. eggs in subsample}}{\text{wt. of subsample}} * \text{total egg mass wt} \right) * 0.945 \right) - \text{dead eggs}$$

where

the first 3 parameters are from egg samples taken from females at spawn time, dead eggs are the number of dead or unfertilized eggs counted at shock time, and the 0.945 value is a correction factor from 1997 and 2000 WDFW studies.

Total egg take is calculated as the total number of live eggs, dead eggs, and all documented egg loss (e.g. spilled at spawn time, etc.). Heath trays are periodically sampled during incubation and dead fry are culled and counted. The number of live eggs less documented fry loss is the estimate of the number of fry ponded. Once fry are ponded, mortalities are counted and recorded daily during the rearing period. Fish are hand counted in the fall prior to their release as they are 100-percent marked. This hand-count less documented mortalities from marking through release is the estimate of smolts released. Survival statistics by origin and life-stage are given in Tables 9.1.1a and 9.1.1b.

**Table 9.1.1a. Cle Elum Supplementation and Research Facility spawning and survival statistics (NoR brood only), 1997 - present.**

Brood Year	Total Collected	Total Morts.	PreSpawn Survival	No. Fish Spawned <sup>1</sup>		% BKD Loss	Total Egg Take	Live Eggs	% Egg Loss <sup>3</sup>	Fry Poned	Live-Egg-Fry Survival	Smolts Released <sup>4</sup>	Fry-Smolt Survival	Live-Egg-Smolt Survival
				Males <sup>2</sup>	Females									
1997	261	23	91.2%	106	132	2.6%	500,750	463,948	7.3%	456,981	98.5%	386,048	84.5%	83.2%
1998	408	70	82.8%	140	198	1.4%	739,802	664,125	10.2%	655,249	98.7%	589,683	90.0%	88.8%
1999	738	24	96.7%	213	222	2.7%	818,816	777,984	5.0%	756,592	97.3%	758,789	100.0%	97.5%
2000	567	61	89.2%	170	278	9.2%	916,292	851,128	7.1%	828,055	97.3%	834,285	100.0%	98.0%
2001	595	171	71.3%	145	223	53.2%	341,648	316,254	7.4%	311,751	98.6%	370,236	100.0%	100.0%
2002	629	89	85.9%	125	261	10.0%	919,776	817,841	11.1%	801,141	98.0%	749,067	93.5%	91.6%
2003	441	54	87.8%	115	200	0.0%	856,574	787,933	8.0%	775,619	98.4%	735,959	94.9%	93.4%
2004	597	70	88.3%	125	245	0.4%	873,815	806,375	7.7%	789,028	97.8%	691,109	87.6%	85.7%
2005	526	57	89.2%	136	241	0.0%	907,199	835,890	7.9%	819,861	98.1%	769,484	93.9%	92.1%
2006	519	45	91.3%	122	239	1.7%	772,357	703,657	8.9%	684,918	97.3%	574,361	83.9%	81.6%
2007	473	49	89.6%	149	216	0.9%	798,729	760,189	4.8%	751,586	98.9%	676,602	90.0%	89.0%
2008	480	38	92.1%	151	253	2.0%	915,563	832,938	9.0%	824,586	99.0%			
2009	486	57	88.3%	142	219	1.4%	850,404	848,339	0.2%					
Mean	517	62	88.0%	141	225	7.0%	785,517	728,200	7.8%	704,614	98.2%	648,693	92.6%	91.0%

**Table 9.1.1b. Cle Elum Supplementation and Research Facility spawning and survival statistics (HoR brood only), 2002 - present.**

Brood Year	Total Collected	Total Morts.	PreSpawn Survival	No. Fish Spawned <sup>1</sup>		% BKD Loss	Total Egg Take <sup>7</sup>	Live Eggs <sup>8</sup>	% Egg Loss <sup>3</sup>	Fry Poned	Live-Egg-Fry Survival	Smolts Released <sup>4</sup>	Fry-Smolt Survival	Live-Egg-Smolt Survival
				Males <sup>2</sup>	Females									
2002	201	22	89.1%	26	72	4.2%	258,226	238,152	7.8%	98,294	98.3%	87,837	89.4%	87.8%
2003	143	12	91.6%	30	51	0.0%	219,901	203,784	7.3%	82,021	98.7%	88,733	100.0%	100.0%
2004	126	19	84.9%	22	49	0.0%	187,406	176,292	5.9%	92,960	98.2%	94,339	100.0%	99.7%
2005	109	6	94.5%	26	45	0.0%	168,160	147,628	12.2%	87,299	98.0%	90,518	100.0%	100.0%
2006	136	21	84.6%	28	41	2.4%	112,576	102,889	8.6%	78,291	97.7%	68,434	87.4%	85.4%
2007	110	15	86.4%	26	35	0.0%	125,755	121,755	3.2%	89,399	99.2%	94,663	100.0%	100.0%
2008	194	10	94.8%	51	67	1.5%	247,503	234,780	5.1%	104,890	98.8%			
2009	164	24	85.4%	30	38	0.0%	148,593	147,458	0.8%					
Mean	148	16	88.9%	30	50	1.0%	183,515	171,592	6.4%	90,451	98.4%	87,421	96.1%	95.5%



1. Total collected minus total mortalities does not equal total spawned. This is because some fish are used in the spawning channel, some have been released back to the river, and some have not been used.
2. Includes jacks.
3. All documented egg loss at spawn time plus dead eggs counted at shock divided by the estimated total egg take.
4. May be greater than fry ponded due to adjusted counts from marking operations.
5. Approximately one-half of these were jacks, many of which were not used in spawning.
6. Approximately 45,000 smolts lost at Jack Creek due to frozen equipment in February, 2006.
7. From 2002 to present this is the estimated total egg take from all HxH crosses. Due to the large surplus of eggs over the approximately 100K needed for the HxH line, many surplus fry were planted in nearby land-locked lakes and some surplus eggs were destroyed.
8. For only those HxH fish which were actually ponded.

**9.1.2) Cause for, and disposition of surplus egg takes.**

*Describe circumstances where extra eggs may be taken (e.g. as a safeguard against potential incubation losses), and the disposition of surplus fish safely carried through to the eyed eggs or fry stage to prevent exceeding of programmed levels.*

Culled as eyed eggs for BKD. Culling is specifically targeted for progeny of females testing for ELISA ranks of 6 or greater and these eggs are destroyed (see also 7.7).

All eggs (deemed not at substantial risk for BKD) which are the result of natural-origin crosses have been used for production. Surplus eggs from hatchery-origin fish (for the research hatchery-control line beyond the ~90,000 fish required to maintain this line) have been destroyed.

**9.1.3) Loading densities applied during incubation.**

*Provide egg size data, standard incubator flows, standard loading per Heath tray (or other incubation density parameters).*

Each heath tray generally contains the eggs from two females (approximately 4,000 to 7,000 eggs). Mean egg size averaged approximately 0.2366 grams per egg for brood years 1997 through 2002. Standard incubator flows to heath tray stacks are 10 gallons per minute.

**9.1.4) Incubation conditions.**

*Describe monitoring methods, temperature regimes, minimum dissolved oxygen criteria (influent/effluent), and silt management procedures (if applicable), and any other parameters monitored.*

Heath stacks are checked daily to monitor and record temperature units. The eggs are thermally controlled to meet ponding criteria of approximately 1,665 total temperature units prior to ponding. Hatchery staff may adjust water temperatures to the heath tray stacks to meet project goals and ponding criteria. Any silt buildup in heath trays is manually flushed as needed. Dissolved oxygen averages about 8 ppm to the heath trays for the duration of incubation and is monitored by automated dissolved oxygen and temperature probes.

**9.1.5) Ponding.**

*Describe degree of button up, cumulative temperature units, and mean length and weight (and distribution around the mean) at ponding. State dates of ponding, and whether swim up and ponding are volitional or forced.*

On average fish have been ponded at about 1,386 fish to the pound between March 15 and April 15 annually after being exposed to an average of 1,654 temperature units. Ponding of swim-up fry is forced except for the progeny of 40-70 adults placed annually into the semi-natural spawning channel. Ponding is based on a manual observation of fish looking for about a 75% yolk-sac absorption rate.

**9.1.6) Fish health maintenance and monitoring.**

*Describe fungus control methods, disease monitoring and treatment procedures,*

*incidence of yolk-sac malformation, and egg mortality removal methods.*

See 7.7.

**9.1.7) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish during incubation.** (e.g. “Eggs will be incubated using well water only to minimize the risk of catastrophic loss due to siltation.”)

See 6.3.

**9.2) Rearing:**

**9.2.1) 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.**

See 9.1.1.

**9.2.2) Density and loading criteria (goals and actual levels).**

*Include density targets (lbs fish/gpm, lbs fish/ft<sup>3</sup> rearing volume, etc).*

The target rearing density for CESRF spring Chinook is 12.0 kg/m<sup>3</sup> of rearing space at the time of release (maximum 45,000 fish per raceway at 33 fish per kg). Average pond rearing densities at release have averaged about 6.8 to 7.3 kg/m<sup>3</sup> or about 60% of the design criteria of 12 kg/m<sup>3</sup>. The juvenile rearing density and loading guidelines used at the facility are based on: standardized agency guidelines, life-stage specific survival studies conducted on-site, staff experience (e.g. trial and error) and other criteria. IHOT standards are followed for: water quality, alarm systems, predator control measures to provide the necessary security for the cultured stock, loading and density.

**9.2.3) Fish rearing conditions**

*(Describe monitoring methods, temperature regimes, minimum dissolved oxygen, carbon dioxide, total gas pressure criteria (influent/effluent if available), and standard pond management procedures applied to rear fish).*

Rearing ponds are monitored daily by staff and mortalities are picked. Monitoring also occurs via automated temperature and dissolved oxygen (designed to maintain a minimum of 7 ppm) probes which feed directly to a hatchery monitoring software system maintained by Technical Systems Inc. Early rearing consists of well water (approx. 50° F); as fish reach approximately 300 fish per pound the water supply is switched over to river water so natural river temperatures are used for the remainder of the rearing regime.

**9.2.4) Indicate biweekly or monthly fish growth information (average program performance), including length, weight, and condition factor data collected during rearing, if available.**

### Food Conversion Efficiency

At the end of each month that fish are in the rearing ponds at the CESRF or the acclimation sites, a sample of fish are weighed and measured to estimate growth. These data, in addition to monthly mortality and pond feed data are entered into the juvenile growth and survival tracking database. Hatchery managers monitor food conversion (total pounds fed during a month divided by the total pounds gained by the fish) to track how well fish are converting feed into body mass and to evaluate the amount of feed that needs to be provided on a monthly basis. Average monthly food conversion and growth statistics for the CESRF facilities by brood year are provided in the following tables and figures.

**Table 9.2.4. Mean food conversion (lbs fed/lbs gained) of CESRF juveniles by brood year and growth month, 1997 – present.**

Brood Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1997	2.2		1.1	0.8	1.2	0.8	1.5	1.5		1.9		5.3	0.7
1998		1.0	0.9	1.0	0.9	0.8	2.4	1.4	2.1	-0.3	1.0	1.2	0.8
1999		1.0	1.1	1.1	1.2	1.5	1.8	1.0		-0.5	0.3	1.7	0.7
2000	0.8	0.8	1.0	1.5	1.2	1.4	2.2	2.0	1.6	2.1	2.5	2.4	
2001	1.1	1.1	2.6	1.1	1.3	1.2	1.6	2.0	2.3	2.5	2.8	0.9	
2002	0.9	1.0	1.4	1.2	1.4	1.1	1.5	2.2	4.0	-1.4	2.9	1.0	
2003	0.6	1.0	0.9	1.4	1.2	1.2	4.6	0.7	0.9	-0.2	1.8	1.0	
2004	0.9	1.0	1.2	1.6	2.4	1.2	1.7	2.0	2.8	0.9	-2.6	1.1	
2005	0.8	0.7	1.3	1.0	1.3	1.2	1.5	-0.8	0.4	-0.4	2.2		
2006	0.8	0.7	0.6	0.9	0.8	1.0	1.6	-1.0	10.1	-2.6	0.6	0.6	
2007	0.7	0.7	0.9	0.9	1.0	0.8	2.2	-1.6	1.9	2.0	0.7	0.9	
2008	0.5	0.6	0.9	0.9	1.0	-17.3	0.8	1.7	-1.1	0.9			
Mean	0.9	0.9	1.1	1.1	1.2	1.1	1.9	0.9	1.7	0.7	1.2	1.2	0.7

### Length and Weight Growth Profiles

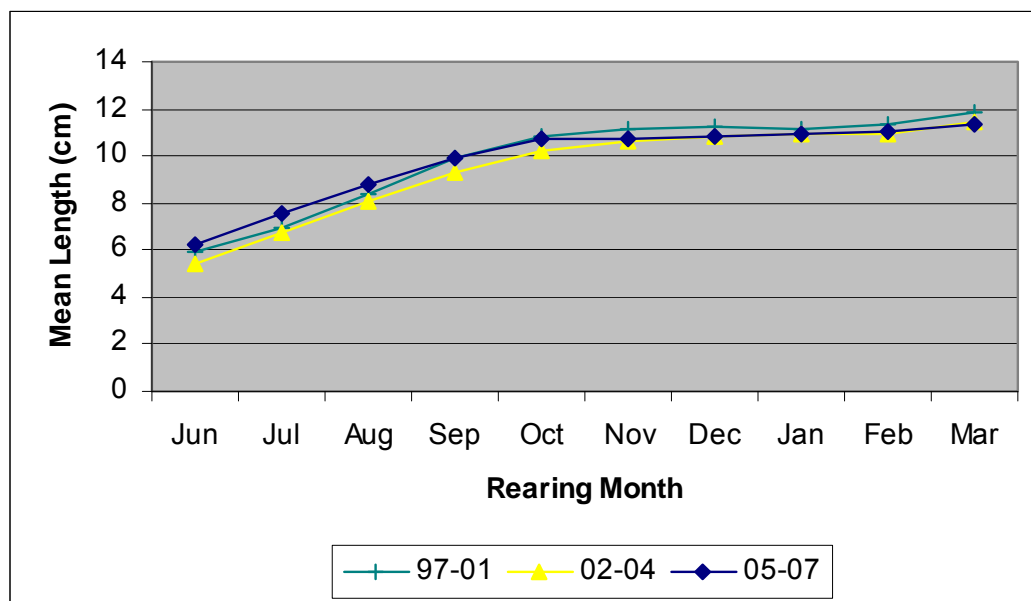


Figure 1. Mean length (cm) of “standard growth treatment (Hi)” CESRF juveniles by brood year and growth month, 1997 - present.

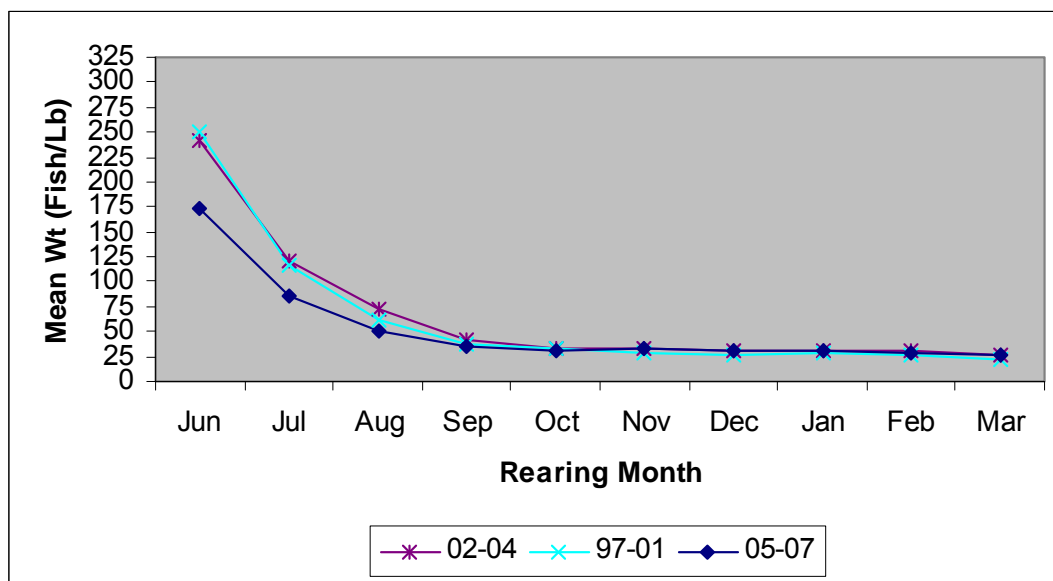


Figure 2. Mean Weight (fish/lb) of “standard growth treatment (Hi)” CESRF juveniles by brood year and growth month, 1997 - present.

Data source: Bosch (2009).

**9.2.5) Indicate monthly fish growth rate and energy reserve data (average program performance), if available.**

*Contrast fall and spring growth rates for yearling smolt programs. If available, indicate hepatosomatic index (liver weight/body weight) and body moisture content as an estimate of body fat concentration data collected during rearing.*

See 9.2.4.

**9.2.6) 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).**

The correct amount and type of food is provided to achieve the desired growth rate, body composition and condition factors for the species and life stages being reared. Rearing period is generally April of BY+1 through March-May of release year (BY+2). Food was generally biomoist #2 and #3 until July of 2006 when this product line was discontinued; since that time feed had generally been Skretting BioVita 2.0 pellets. Other data are available from YKFP via monthly growth and survival reports posted to the data warehouse section of the project web site (<http://www.ykfp.org/datawh/>). Also see 9.2.4 above. Additional documentation is available from Cle Elum Hatchery staff.

**9.2.7) Fish health monitoring, disease treatment, and sanitation procedures.**

See 7.7.

**9.2.8) Smolt development indices (e.g. gill ATPase activity), if applicable.**

The migratory state of the release population is determined by volitional release. The target date for initiation of volitional release is March 15 (after approximately 4-6 weeks of acclimation) to May 15th after which fish that have not emigrated are forced out.

**9.2.9) Indicate the use of "natural" rearing methods as applied in the program.**

See 6.3.

For the 1997-2001 broods, one-half of the rearing ponds at CESRF and the acclimation sites were semi-natural treatments (i.e, painted substrate, cover, structure, underwater feeding). Results from this experiment were published in Fast et al. (2008).

**9.2.10) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse genetic and ecological effects to listed fish under propagation.** (e.g. "Fish will be reared to sub-yearling smolt size to mimic the natural fish emigration strategy and to minimize the risk of domestication effects that may be imparted through rearing to yearling size.")

See 6.3.

**SECTION 10. RELEASE**

**Describe fish release levels, and release practices applied through the hatchery program.**

*Specify any management goals (e.g. number, size or age at release, population uniformity, residualization controls) that the hatchery is operating under for the hatchery stock in the appropriate sections below.*

**10.1) Proposed fish release levels.** (Use standardized life stage definitions by species presented in **Attachment 2**. "Location" is watershed planted (e.g. "Elwha River").)

Age Class	Maximum Number	Size (fpp)	Release Date	Location
Eggs				
Unfed Fry				
Fry				
Fingerling				
Yearling	810000	15	March 15 (volitional)	Yakima and Teanaway (See 1.5)

Cle Elum Hatchery program fish are volitionally released from Easton Pond and Clark Flat Acclimation facilities (Yakima River) and Jack Creek Acclimation facility (Teaway River). Fish are volitionally released at all three sites beginning March 15.

The original experimental design calls for the cumulative release of 810,000 smolts annually divided into 3 approximately equal groups released from each of three acclimation sites associated with the CESRF.

**10.2) Specific location(s) of proposed release(s).**

**Stream, river, or watercourse:** *(include name and watershed code (e.g. WRIA) number)*

**Release point:** *(river kilometer location, or latitude/longitude)*

**Major watershed:** *(e.g. "Skagit River")*

**Basin or Region:** *(e.g. "Puget Sound")*

Cle Elum Hatchery program fish are volitionally released from Easton Pond and Clark Flat Acclimation facilities (Yakima River) and Jack Creek Acclimation facility (Teaway River). Fish are volitionally released at all three sites beginning March 15. See 1.5.

**10.3) Actual numbers and sizes of fish released by age class through the program.**

*For existing programs, provide fish release number and size data for the past three fish generations, or approximately the past 12 years, if available. Use standardized life stage definitions by species presented in **Attachment 2**. Cite the data source for this information.*

Data source: (Link to appended Excel spreadsheet using this structure. Include hyperlink to main database)

**CESRF Smolt Releases**

The number of release groups and total number of fish released diverged from facility goals in some years. In brood year 1997, the Jack Creek acclimation facility was not yet complete and project policy and technical teams purposely decided to under-collect brood stock to allow a methodical testing of the new facility's operations with less risk to live fish, which resulted in the stocking of only 10 of the 18 raceways. In brood year 1998, the project did not meet facility release goals due to a biological specification that no more than 50% of returning wild fish be taken for brood stock. As a result only 16 raceways were stocked with progeny of the 1998 brood. In the same year, raceway 4 at the Jack Creek acclimation site suffered mechanical failures causing loss of flow and reduced oxygen levels and resulted in the loss of approximately one-half the fish in this raceway prior to release. In the drought year of 2001, a large number of returning adults presented with high enzyme-linked immunosorbent assay (ELISA) levels of *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease (BKD). The progeny of these females were purposely destroyed. As a result, only nine raceways were stocked with fish. The project decided to use the fish from an odd raceway for a predator avoidance training sub-experiment (these fish were subsequently acclimated and released from the Easton acclimation site).

**Table 10.3a. CESRF total (age-1 smolt) releases by brood year, treatment, and acclimation site.**

Brood Year	Treatment		Acclimation Site			Total
	Control <sup>1</sup>	Treatment <sup>2</sup>	CFJ	ESJ	JCJ	
1997	207,437	178,611	229,290	156,758		386,048
1998 <sup>3</sup>	284,673	305,010	221,460	230,860	137,363	589,683
1999	384,563	374,226	232,563	269,502	256,724	758,789
2000	424,554	409,731	285,954	263,061	285,270	834,285
2001 <sup>4</sup>	183,963	186,273	80,782	39,106	250,348	370,236
2002	420,764	416,140	266,563	290,552	279,789	836,904
2003	414,175	410,517	273,377	267,711	283,604	824,692
2004 <sup>5</sup>	378,740	406,708	280,598	273,440	231,410	785,448
2005	431,536	428,466	287,127	281,150	291,725	860,002
2006	351,063	291,732	209,575	217,932	215,288	642,795
2007	387,055	384,210	265,907	254,540	250,818	771,265
Mean	351,684	344,693	239,381	231,328	248,234	696,377

**Table 10.3b. CESRF average pond densities at release by brood year, treatment, and acclimation site.**

Brood Year	Treatment		Acclimation Site		
	Control <sup>1</sup>	Treatment <sup>2</sup>	CFJ	ESJ	JCJ
1997	41,487	35,722	38,215	39,190	
1998 <sup>3</sup>	35,584	38,126	36,910	38,477	34,341
1999	42,729	41,581	38,761	44,917	42,787
2000	47,173	45,526	47,659	43,844	47,545
2001 <sup>4</sup>	41,116	41,667	40,391	6,518	41,725
2002	46,752	46,238	44,427	48,425	46,632
2003	46,019	45,613	45,563	44,619	47,267
2004 <sup>5</sup>	42,082	45,190	46,766	45,573	38,568
2005	47,948	47,607	47,855	46,858	48,621
2006	39,007	32,415	34,929	36,322	35,881
2007	43,006	42,690	44,318	42,423	41,803
Mean	42,991	42,034	42,345	43,065	42,517

1. Brood years 1997-2001: Optimum Conventional Treatment (OCT). Brood Years 2002-2004: Normal (High) growth. Brood Year 2005: Normal feed at accl. sites.
2. Brood years 1997-2001: Semi-natural Treatment (SNT). Brood Years 2002-2004: Slowed (Low) growth. Brood Year 2005: saltwater transition feed at accl. sites.
3. At the Jack Creek acclimation site only 4 of 6 raceways were stocked, and raceway 4 suffered mechanical failures resulting in the loss of about 20,000 OCT (control) fish.
4. High BKD incidence in adult broodstock reduced production to just 9 ponds (Clark Flat 1-2, Jack Creek, and Easton). Easton ponds were used for predator avoidance trained (PAT) fish and a single Cle Elum pond was spread between 6 ponds at Easton with crowders used to simulate pond densities for fish at other acclimation sites. These releases were excluded from mean pond density calculations by treatment.
5. At the Jack Creek acclimation site raceway 3 suffered mechanical failures resulting in the loss of about 45,000 high-growth (control) fish.

Data source: Bosch (2009).



**10.4) Actual dates of release and description of release protocols.**

*Provide the recent five year release date ranges by life stage produced (mo/day/yr). Also indicate the rationale for choosing release dates, how fish are released (volitionally, forced, volitionally then forced) and any culling procedures applied for non-migrants.*

All fish released as age-1 smolts. Volitional release date range by release year for recent years were as follows:

2003: March 15 – May 15, except for ~45,000 fish reared at Easton March 15-March 28.

2004: March 15 – May 14

2005: March 9 – April 27

2006: March 15 – May 15

2007: March 15 – May 15

2008: March 15 – May 14

2009: March 15 – May 15

Fish are transferred to remote acclimation facilities during January-February (4-6 weeks acclimation); and are released volitionally on the target date of March 15th, and by May 15th fish are forced out. Fish are released volitionally to mimic the natural fish outmigration period. The volitional release period coincides with the natural migration of naturally produced fish. Fish release size and timing is based on YKFP on-going studies conducted since the early 1990s in the upper Yakima basin.

**10.5) Fish transportation procedures, if applicable.**

*Describe fish transportation procedures for off-station release. Include length of time in transit, fish loading densities, and temperature control and oxygenation methods.*

Equipment Type	Capacity (gallons)	Supplemental Oxygen (y/n)	Temperature Control (y/n)	Normal Transit Time (minutes)	Chemical(s) Used	Dosage (ppm)
Adult Transfer Tanker Truck	700	Y	N	60	Light dose MS	
Juvenile Transfer Tanker Truck	2500	Y	N	40		

**10.6) Acclimation procedures (methods applied and length of time).**

Fish are transferred in mid January to February to acclimate fish for a 4-6 week period; and volitional release is initiated on March 15 through May 15; and on May 15 remaining fish forced out of ponds per Washington Department of Ecology water use permit.

**10.7) Marks applied, and proportions of the total hatchery population marked, to identify hatchery adults.**

Marking techniques are used to distinguish among hatchery population segments with 100% of the hatchery fish released being marked so that they can be distinguished from the natural population. The CESRF program has used adipose fin-clips, coded-wire tags (CWT), passive integrated transponder (PIT) tags, and visual-implant elastomer (VIE) tags in combination for Yakima Spring Chinook HGMP, May 10, 2009

monitoring and evaluation purposes. Marking schemes by brood year are available in Appendix A of Bosch (2009) and are also submitted electronically to the regional [PTAGIS](#) (PIT) and [RMPC](#) (CWT) web sites and to BPA in annual reports (for most recent see Sampson et al. 2009).

**10.8) Disposition plans for fish identified at the time of release as surplus to programmed or approved levels.**

Current five year plan sets forth level of broodstock/egg acquisition to meet program objectives relative to 810K smolt production. Actual releases by year were given in 10.3 above. Surpluses of natural-origin (NOR) or supplementation (parents were NOR fish) broodstock are released to the river as soon as they are determined to be surplus to spawning needs. In years when NOR production has resulted in surplus production beyond the target rearing density of 45,000 fish per raceway (even after release of surplus adults), the co-managers have agreed to relax rearing densities (see 10.3). Surplus HxH (hatchery control line) fish are distributed to YN tribal members for subsistence use following a 3-week holding period to allow MS-222 treatment at collection to dissipate. If not suitable for consumption, surplus HxH fish are destroyed.

**10.9) Fish health certification procedures applied pre-release.**

See 7.7.

**10.10) Emergency release procedures in response to flooding or water system failure.**

Every effort will be made to avoid emergency releases. Emergency releases, if necessary, would be accomplished by removal of outlet screens and damboards at the lower end of the raceways, and fish would be allowed to volitionally emigrate into the river.

**10.11) 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.**

*(e.g. “All yearling coho salmon will be released in early June in the lower mainstem of the Green River to minimize the likelihood for interaction, and adverse ecological effects, to listed natural Chinook salmon juveniles, which rear in up-river areas and migrate seaward as sub-yearling smolts predominately in May”).*

See 6.3.

**SECTION 11. MONITORING AND EVALUATION OF PERFORMANCE INDICATORS**

*This section describes how “Performance Indicators” listed in Section 1.10 will be monitored. Results of “Performance Indicator” monitoring will be evaluated annually and used to adaptively manage the hatchery program, as needed, to meet “Performance Standards”.*

**11.1) Monitoring and evaluation of “Performance Indicators” presented in Section 1.10.**

**11.1.1) Describe plans and methods proposed to collect data necessary to respond to each “Performance Indicator” identified for the program.**

Microsoft Access applications have been developed to track this program from broodstock collection at Roza Dam through spawning and rearing at the hatchery and release from the acclimation sites. PIT tags are inserted into all brood stock collected at Roza Dam to allow tracking of fish through the collection, spawning and rearing process. Data from these on-site data capture systems are logged to the project web site (ykfp.org) and into historical Excel tables which are updated annually and summarized in annual reports, e.g., Bosch (2009).

The YKFP spring Chinook monitoring and evaluation plan is fully described in: Busack, Craig; Todd Pearsons, Curt Knudsen, Steve Phelps, Washington Department of Fish and Wildlife, Bruce Watson, Mark Johnston, Yakama Nation, U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife. 1997. Yakima Fisheries Project spring Chinook supplementation monitoring plan. Project Number 195-065, Contract Number DE-BI79-1996 BPA64878. <http://www.efw.bpa.gov/Publications/P64878-1.pdf>.

Additional information can be found in the project's annual reports to BPA (for most recent see Sampson et al. 2009) which include the report, Natural Production and Domestication Monitoring of the Yakima Spring Chinook Supplementation Program, Yakima/Klickitat Fisheries Project Monitoring Implementation Planning Team, Revised Dec 21, 2005 which is attached to this HGMP as Appendix A.

**11.1.2) Indicate whether funding, staffing, and other support logistics are available or committed to allow implementation of the monitoring and evaluation program.**

BPA / NPCC Fish & Wildlife Program funding is used for Yakima Fisheries Project M&E activities (project # 199506325). The project is included in the Columbia River Fish Accords and funding is expected to continue through at least 2017.

**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.**

*(e.g. "The Wenatchee River smolt trap will be continuously monitored, and checked every eight hours, to minimize the duration of holding and risk of harm to listed spring Chinook and steelhead that may be incidentally captured during the sockeye smolt emigration period.)"*

See 6.3.

## **SECTION 12. RESEARCH**

*Provide the following information for any research programs conducted in **direct association with the hatchery program described in this HGMP**. Provide sufficient detail to allow for the independent assessment of the effects of the research program on listed fish. If applicable, correlate with research indicated as needed in any ESU hatchery plan approved by the co-managers and NMFS. Attach a copy of any formal research proposal addressing activities covered in this section. Include estimated take levels for the research program with take levels provided for the associated hatchery program in **Table 1**.*

**12.1) Objective or purpose.**

*Indicate why the research is needed, its benefit or effect on listed natural fish populations, and broad significance of the proposed project.*

After years of planning and design, an Environmental Impact Statement (EIS) was completed in 1996 and the CESRF was authorized under the NPCC’s Fish and Wildlife Program with the stated purpose being “to test the assumption that new artificial production can be used to increase harvest and natural production while maintaining the long-term genetic fitness of the fish population being supplemented and keeping adverse genetic and ecological interactions with non-target species or stocks within acceptable limits”. In order to meet the project’s stated purpose, research has always been an integral component of this program as evidenced by the carefully selected name for the facility: Cle Elum Supplementation and Research Facility.

**12.2) Cooperating and funding agencies.**

Bonneville Power Administration (Fish & Wildlife Program)- funding agency

Yakama Nation- comanager and lead entity

Washington Department of Fish & Wildlife- comanager

NOAA Fisheries – research cooperator

**12.3) Principle investigator or project supervisor and staff.**

Mel Sampson, YN, Project Manager (Chair of Policy Group)

John Easterbrooks, WDFW, Policy Group Member

Dr. Dave Fast, YN, Scientific and Technical Advisory Committee (Chair)

Andrew Murdoch, WDFW, Scientific and Technical Advisory Committee

Monitoring and Implementation Planning Team (MIPT) consisting of several scientists from YN and WDFW

**12.4) Status of stock, particularly the group affected by project, if different than the stock(s) described in Section 2.**

Same as Section 2.

**12.5) Techniques: include capture methods, drugs, samples collected, tags applied.**

The wide breadth of research activities associated with the YKFP requires a wide array of field sampling activities. Sampling locations and field activities include:

**Spawning Surveys**

Spring Chinook surveys will be conducted annually on the American, Little Naches, Bumping, Rattlesnake and Naches rivers in the Naches River Basin. Surveys in the American, Little Naches, Rattlesnake and the two upper stretches of the Bumping River will be conducted on

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foot. Surveys in the Naches and lower section of the Bumping River will be conducted by raft. Each section or reach will be surveyed weekly throughout the spawning season. Surveys will begin in late July and end in late September.

Spring Chinook surveys will be conducted annually on the Teanaway, Cle Elum and Yakima rivers in the upper Yakima River Basin. Surveys in the Cle Elum and Yakima rivers will be conducted by raft. A walking survey will be conducted in the Teanaway River. Each reach will be surveyed weekly throughout the spawning season. Surveys will begin in late August and end in early October.

Data, usually length, sex and scales for age analysis, will be collected from spawned-out carcasses.

### **Spring Chinook Predator Electrofishing Surveys**

Predatory fish have been identified as strong interactors that could potentially limit the success of spring Chinook salmon supplementation efforts in the Yakima Basin (Busack et al. 1997; Pearsons et al. 1998). Predatory fishes have been implicated as a source of smolt mortality throughout the mid- and lower Columbia and Snake rivers (Vigg, et al. 1991; Tabor, et al. 1993; Ward, et al. 1995). Low smolt survival through the Yakima River, especially between the city of Yakima and the confluence of the Columbia River, has been attributed to predation by large numbers of native and non-native piscivorous fishes. Northern pikeminnow (*Ptychocheilus oregonensis*) are the primary piscivorous fish species present in the mid-reaches of the Yakima River (McMichael, et al. 1998).

Monthly boat electrofishing surveys from March through June in nine river sections are planned in the lower Yakima River from RM 0-103 to census predatory fishes (Sampson et al. 2009). An experimental design that combines stomach samples and mark-recapture population estimates will estimate the impact of predation on Yakima River salmon and steelhead smolts.

### **Non-Target Taxa Monitoring**

Concerns that supplementation of anadromous fish in the Yakima Basin could negatively affect other non-target fish taxa (NTT) prompted the development of a risk containment monitoring program for the YKFP (BPA 1996; Busack, et al. 1997; Ham and Pearsons 2001). Risk containment monitoring was initiated in 1990 as part of the program. Containment objectives were established to serve as a benchmark against which changes in the population status of NTT could be judged relative to baseline conditions (Ham and Pearsons 2001). This program will continue to be implemented.

Evaluating the population status of NTT necessitates a wide array of sampling techniques and locations. In Yakima River tributary streams, mark-recapture electrofishing protocols in established 200-meter (218-yard) long index monitoring sites will be performed once annually, generally between July and August (e.g., Taneum Creek, Cowiche Creek, Manastash Creek, Cabin Creek, Swauk Creek, Wilson Creek, the mainstem, Middle, West, and North Fork Teanaway rivers, Stafford Creek, Umtanum Creek, and Jungle Creek). Also, approximately 600 resident rainbow trout will be captured by electrofishing and PIT tagged each spring in the North

Fork Teanaway River just downstream from the Jack Creek acclimation facility and in the Middle Fork Teanaway River. These fish will be tracked over time to see if stocking Chinook affects growth rates.

In the mainstem Yakima River, five index reaches ranging from 2.5 to 4.5 miles long will also be sampled once annually during September and October using a drift boat-mounted electrofishing unit. Information collected from tributary and mainstem index sites will include abundance and size structure of salmonids and relative abundance and size structure of common native taxa. Additional sampling of the stream margins within mainstem index reaches will also be performed using a backpack electrofisher to obtain length at age information for small salmonids.

All surveys will be conducted following the guidelines in the NMFS electrofishing guidelines (NMFS, 2000), and all work will be conducted in a manner that minimizes electrofishing injury to stream salmonids (McMichael et al. 1998).

Distributional overlap between supplemented salmon and bull trout will be inventoried by annual snorkeling surveys. A systematic sample of 0.6-mile long reaches and the entire rearing area of bull trout in the North Fork Teanaway River will be inventoried by snorkeling during late summer (generally September). Night snorkeling is recommended as the best low impact sampling strategy for bull trout (Thurow et al. 2006). Two divers equipped with underwater lights will move upstream and count all fish observed and estimate the length of all bull trout encountered. All bull trout observed will be reported to USFWS annually.

### **Domestication Research**

Approximately 10 wild female and 10 wild male adult spring Chinook salmon will be collected annually in the Naches River drainage to provide offspring for ongoing domestication research (Naches control line; Busack et al. 2006). Collections will generally be performed between September 1 and September 15. Collection of partially-spawned fish will use tangle nets and dip nets. Fish will be visually identified (snorkeling or above surface) and captured using drift net techniques such that there is minimal or no incidental catch of other salmonid species. When nets are used in deep water habitats (e.g., pools), the area is first surveyed by snorkeling to ensure that no bull trout are present. If bull trout are observed, the area is not sampled. If no bull trout are present, up to three snorkelers remain in the water for the entire length of time the net is set to assist in the capture of Chinook broodstock. The tangle nets have a 4-inch mesh size, which would allow any juvenile or subadult steelhead to pass through unharmed. Tangle nets will not be left unattended and will not generally be in the water for more than two minutes per drift.

The effects of predation mortality on spring Chinook salmon fry will be studied at the Cle Elum facility. Wild rainbow trout and torrent sculpin predators will be collected from March through May using hook-and-line or electrofishing in tributaries or the mainstem Yakima upstream from the hatchery water intake structure. Predators will be collected, transported, released in net pens in a hatchery raceway, predation mortality examined, and finally, re-distributed back into the river. Collections will be restricted to areas upstream from the hatchery water intake to minimize the potential of bringing pathogens into the facility. All electrofishing collections will be conducted following the suggestions provided in the NMFS electrofishing guidelines (NMFS, Yakima Spring Chinook HGMP, May 10, 2009

2000), and all work will be conducted in a manner that minimizes electrofishing injury to stream salmonids (McMichael et al. 1998).

### **Monitoring of Residual and Precocious male Spring Chinook and Competition Indices**

Select ecological interactions and spring Chinook salmon residual/precocious male abundance are monitored as part of the YN's supplementation monitoring program, and will continue to be monitored in the future. Monitoring these variables is part of an effort to help evaluate the factors that contribute to or limit supplementation success. Ecological interactions monitored are prey consumption, competition for food, and competition for space. Spring Chinook salmon life-history forms that have the potential to be influenced by supplementation and that pose ecological and genetic risks are also monitored (residuals and precocious males). Residual spring Chinook salmon do not migrate to the ocean during the normal emigration period and continue to rear in freshwater.

Incidence of predation of natural origin rainbow trout/steelhead (*Oncorhynchus mykiss*) and Chinook salmon by residual hatchery spring Chinook salmon will be evaluated in the Yakima River Basin beginning in mid-March, when the size differential between hatchery and natural origin spring Chinook is the greatest, and will continue throughout the summer and fall, ending in mid to late September. Sampling to evaluate food competition will be conducted concurrently. During this period approximately 500 juvenile spring Chinook and 30 rainbow trout will be sampled via backpack electrofishing. Each specimen's stomach contents will be collected via gastric evacuation, and basic metrics recorded prior to their release. Fluctuation of food consumption throughout a 24-hour period will be evaluated between mid-September and mid-October when an additional 240 juvenile spring Chinook will be sampled via drift boat (while performing tasks under **Non-target Taxa Monitoring**) and backpack electrofishing in the upper Yakima. These samples will be evenly distributed throughout six distinct time intervals.

Data collection for the subsequent evaluation of juvenile Chinook microhabitat utilization and competition for space will be conducted concurrently in the upper Yakima, from July through September. Select sections are snorkeled for the presence of juvenile spring Chinook. When spring Chinook are encountered a variety of measurements will be made at that location (e.g., specimen size and activity, distance to nearest competitor, relative location within a pod, location within the water column, cover, flow, etc.) Approximately 300 locations will be measured yearly.

To determine available and suitable habitat characteristics for juvenile spring Chinook, a number of variables will be measured along 45 transects evenly distributed in the mainstem Yakima and Cle Elum rivers. Measurements (similar to those of the microhabitat protocol) will be made at one meter (3.28 foot) increments along each transect, once in the summer (July-August) and again in the fall (September-November).

Invertebrate drift will be measured at suitable locations of variable flow within the mainstem Yakima and Cle Elum rivers between the months of July and September. Invertebrate drift nets totaling approximately 24 square meters (258 square feet) will be anchored with half-inch rebar at various locations and left (monitored) in the flow for a period of four hours.

Residual hatchery spring Chinook abundance and distribution will be evaluated between the months of June and August in the North Fork of the Teanaway River and in the mainstem Yakima River. Snorkeling surveys will be conducted once each month in four 100-yard index sites in the North Fork of the Teanaway River, and in one index site in the mainstem Yakima River between RM 194 and RM 196. Additionally, spot checks will be performed upstream of North Fork Teanaway index sites to determine the location of the most upstream area inhabited by residual hatchery spring Chinook.

The abundance of precocious spring Chinook males and the distribution of hatchery spring Chinook will be evaluated at the peak of spawning activity (mid-September) each year. Snorkeling surveys will be conducted along the entire span of the upper Yakima River between Easton Dam and the Town Diversion north of Ellensburg. Redds deemed active (those with an adult present) are observed, and the presence of any precociously mature males noted.

### **Stream Sedimentation Impact Monitoring**

Stream sediment loads associated with the operation of dams and other anthropogenic factors (e.g., logging, agriculture, and road building) will be monitored. This work is conducted jointly by the YN, U.S. Forest Service, and others. Gravel samples are collected from streams in the Little Naches and upper Yakima River watersheds. The core sampler removes a sample about 1 ft in depth and 10 inches around, with four samples being taken on 3 different riffles for a total of 12 samples from each stream sample area. Gravel samples are then processed in the lab.

#### **12.6) Dates or time period in which research activity occurs.**

Year round unless specified in section 12.5.

#### **12.7) Care and maintenance of live fish or eggs, holding duration, transport methods.**

### **Non-Target Taxa Monitoring**

For ecological interactions studies and the non-target taxa monitoring program, live fish are generally held captive for relatively short periods (<1hr). Detailed sampling protocols are presented in Temple and Pearsons (2007). Briefly, population estimates for non-target populations are generated using mark-recapture methods, and captured fish are held in perforated livewells in the stream margins (Tributaries) or in an aerated livewell (mainstem Yakima River). Fish handling procedures are strictly adhered to (Nickum 2004; CCAC 2005; Temple and Pearsons 2007).

### **Domestication Research**

For predation studies conducted under the domestication research task, rainbow trout and torrent sculpin predators are collected using backpack electrofishing or hook and line sampling in the mainstem Yakima River or tributary streams located upstream from the CESRF water intake structure, and are transported in aerated livewells to the supplementation facility where they are



held in net pens located in hatchery raceways, predator trials conducted, and released near their point of capture. Detailed protocols are presented in Pearsons et al. (2007).

### **12.8) Expected type and effects of take and potential for injury or mortality.**

Incidental take associated with non-target taxa monitoring, domestication research, monitoring of residual and precocious male spring Chinook, and competition indices activities combined are minimal. There is a low potential to injure steelhead juveniles because 1) observed injury rates of *O.mykiss* have been low, and 2) there likely are few steelhead in the areas these activities are performed.

### **12.9) Level of take of listed fish: number or range of fish handled, injured, or killed by sex, age, or size, if not already indicated in Section 2 and the attached “take table” (Table 1).**

#### **Spawning Surveys**

Spawning surveys are conducted from foot or by inflatable rafts and spring Chinook redds are enumerated. With the exception of spawned out carcasses, no fish are handled during sampling.

#### **Spring Chinook Predator Electro-fishing Surveys**

During the spring electro-fishing studies on Northern Pike Minnow, other species are susceptible to the electric field including *O. mykiss*. During a typical day on the river about 2-6 adults may be stunned for a short duration, but they are only in the field for a very short period. Great effort has been exercised in minimizing any injuries to adults by halting shocking operations upon discovery of adult presence. The short duration of stun indicates a low level of impact to these fish and negligible damage via electro-shocking runs. Furthermore adult steelhead are not handled or taken onboard the vessel at any time.

#### **Non-Target Taxa Monitoring**

On average, approximately 6118 rainbow trout are handled under the NTT program annually (annual average between 2000 and 2007; mean size is 118mm FL in tributaries and 250mm FL in the mainstem). Field data indicates sub-lethal injuries averaged 1.1% of the fish handled, while lethal injuries averaged 0.4% of the fish handled annually. Steelhead are thought to comprise less than 1% of the *O. mykiss* in the Upper Yakima Basin. Thus lethal and sub-lethal injuries equate to 0.65 and 0.27 steelhead injured or killed annually, or less than 1% of potential steelhead in the Upper Yakima Basin.

During September each year, the entire rearing area, or nine, 200m index reaches are snorkeled to enumerate bull trout abundance. All fish taxa observed are recorded. Fish are not handled under this activity. The annual average number of *O. mykiss* observed while snorkeling is 412 fish (maximum was 1080). Assuming 1% are steelhead, the maximum number of steelhead juveniles that may be observed under the snorkeling activity is 11 fish.

## **Monitoring of Residual and Precocious Male Spring Chinook and Competition Indices**

Few *O. mykiss* are handled under this task, and those that are, are typically collected in conjunction with the NTT monitoring program and lethal and sub-lethal injury rates are included under NTT in section 12.9 above. (Typically, data are collected on the same individual fish concurrently for the NTT monitoring activity and for the monitoring of residual and precocious male spring Chinook and competition indices activities).

### **Domestication Research**

Naches broodstock collection activities are generally performed during September of each year, generally several months before the arrival of summer steelhead spawning adults. Broodstock collection activities (described in section 12.5) use large tangle net sizes that allow juvenile sized fish to pass through unharmed. No juvenile *O. mykiss* have been observed, captured or injured from this sampling in previous years.

For the research examining predation mortality, approximately 500 *O. mykiss* juveniles are sampled annually using electrofishing or hook and line sampling. Since it is thought that less than 1% of *O. mykiss* handled are steelhead, and applying the injury rates presented under the NTT task above, less than 1 steelhead would exhibit sub-lethal or lethal injuries associated with this research activity.

#### **12.10) Alternative methods to achieve project objectives.**

Alternative methods were explored during the extensive planning and public comment period and were documented and publicly reviewed during the EIS process (BPA 1996). See also 1.16 above.

#### **12.11) List species similar or related to the threatened species; provide number and causes of mortality related to this research project.**

The resident form of *O. mykiss* is abundant in the Upper Yakima Basin (mainstem Yakima River abundance estimates based on efficiency expansions average approximately 30,000 rainbow trout between Roza Dam and the Cle Elum River confluence annually and a greater number in tributary streams; Temple et al. 2007) and it is thought 99% of them are of the resident form. On average, approximately 6118 rainbow trout are handled under the NTT program annually (annual average between 2000 and 2007; mean size is 118mm FL in tributaries and 250mm FL in the mainstem). Documented sub-lethal injuries averaged 3.2%% (mean of 5.1% injury rates in tributaries and 1.2% injury rate of rainbow trout <250 mm in the mainstem; McMichael et al.1998) of the trout handled, while lethal injuries averaged 0.4% of the trout handled annually. Applying these injury rates, on average, 24 and 196 resident rainbow trout exhibit lethal and sub-lethal injuries associated with this research activity. If we apply the expected steelhead proportion to these numbers (1%), then less than 3 juvenile steelhead exhibits lethal or sub-lethal injuries.

**12.12) Indicate risk aversion measures that will be applied to minimize the likelihood for adverse ecological effects, injury, or mortality to listed fish as a result of the proposed research activities.**

*(e.g. “Listed coastal cutthroat trout sampled for the predation study will be collected in compliance with NMFS Electrofishing Guidelines to minimize the risk of injury or immediate mortality.”).*

All field sampling associated with the non-target taxa monitoring, Spring Chinook Residual/Precocial Monitoring and Competition Indices, and domestication research activities follow NMFS electrofishing guidelines (NMFS 2000), stringent field sampling protocols (Temple and Pearsons 2007), and fish handling guidelines (Stickney 1983; Nickum 2004; CCAC 2005; Temple and Pearsons 2007) to minimize the risk of injury or immediate mortality. We studied the effects of backpack and driftboat electrofishing on trout and salmon prior to supplementation and found them to be acceptably low (McMichael et al. 1998). Furthermore, population trends do not indicate that electrofishing is impacting population size. See also 6.3.

### **SECTION 13. ATTACHMENTS AND CITATIONS**

*Include all references cited in the HGMP. In particular, indicate hatchery databases used to provide data for each section. Include electronic links to the hatchery databases used (if feasible), or to the staff person responsible for maintaining the hatchery database referenced (indicate email address). Attach or cite (where commonly available) relevant reports that describe the hatchery operation and impacts on the listed species or its critical habitat. Include any EISs, EAs, Biological Assessments, benefit/risk assessments, or other analysis or plans that provide pertinent background information to facilitate evaluation of the HGMP.*

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See also <http://www.efw.bpa.gov/searchpublications/> and [ykfp.org](http://ykfp.org) “Technical reports and publications” for additional references on this project.



**SECTION 14. 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:

Certified by \_\_\_\_\_ Date: \_\_\_\_\_

**Table 1.** Yakima Basin Spring Chinook Activity Take Table Summary. Estimated annual take of *O. Mykiss* for all activities associated with the Cle Elum Supplementation and Research Facility, including research, monitoring and evaluation conducted under BPA project id 199506325.

Activity Description	Amount of Annual Take	Life Stage of Take	Type of Take (a-h)	Associated Permit or HGMP
Broodstock Collection (Roza Dam)	<500 <1	Adult	d g	BPA also holds Section 10 permit 1426 for steelhead adult collection, radio-tagging, and release at Roza Dam (expires 12/31/2007) as part of the overall Yakima Fisheries Project
Spawning Ground Surveys	0 0	Adult Juvenile	a a	
Naches control line work	10	Juvenile	a	
Spawning Channel Studies (Hatchery/Wild Repro. Success Studies)	<1	Juvenile	c	
Species Interactions-NTTOC (Electrofishing, Snorkeling, PIT-tagging)	11 61 <1	Juvenile	a d g	
Species Interactions-NTTOC (Electrofishing, Snorkeling, PIT-tagging)	<5 <1	Adult	a g	
Domestication (predation mortality studies)	1 3 <1	Juvenile	b c g	
Residual/Precocial Monitoring and Competition Indices	10 <1 <1	Juvenile	a d g	
Roza juvenile sampling	<500 <3	Juvenile	d g	
Chandler juvenile sampling	<10,500 <50	Juvenile	d g	
Sediment sampling	<1	Juvenile	a	
Avian Predation monitoring	0 0	Adult Juvenile	a a	
Fish Predation monitoring (electroshocking to monitor abundance)	<200 0	Adult	a g	

- a. Contact with listed fish through stream surveys, carcass and mark recovery projects, or migrational delay at weirs.
- b. Take associated with weir or trapping operations where listed fish are captured and transported for release.
- c. Take associated with weir or 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.
- f. Intentional mortality of listed fish, usually as a result of spawning as broodstock.
- g. Unintentional mortality of listed fish, including loss of fish during transport or holding prior to spawning or prior to release into the wild, or, for integrated programs, mortalities during incubation and rearing.
- h. Other takes not identified above as a category.

**Instructions:**

1. An entry for a fish to be taken should be in the take category that describes the greatest impact.
2. Each take to be entered in the table should be in one take category only (there should not be more than one entry

*for the same sampling event).*

*3. If an individual fish is to be taken more than once on separate occasions, each take must be entered in the take table.*

## Attachment 1. Definition of terms referenced in the HGMP template.

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Augmentation - The use of artificial production to increase harvestable numbers of fish in areas where the natural freshwater production capacity is limited, but the capacity of other salmonid habitat areas will support increased production. Also referred to as “fishery enhancement”.

Critical population threshold - An abundance level for an independent Pacific salmonid population below which: compensatory processes are likely to reduce it below replacement; short-term effects of inbreeding depression or loss of rare alleles cannot be avoided; and productivity variation due to demographic stochasticity becomes a substantial source of risk.

Direct take - The intentional take of a listed species. Direct takes may be authorized under the ESA for the purpose of propagation to enhance the species or research.

Evolutionarily Significant Unit (ESU) - NMFS definition of a distinct population segment (the smallest biological unit that will be considered to be a species under the Endangered Species Act). A population will be/is considered to be an ESU if 1) it is substantially reproductively isolated from other conspecific population units, and 2) it represents an important component in the evolutionary legacy of the species.

Harvest project - Projects designed for the production of fish that are primarily intended to be caught in fisheries.

Hatchery fish - A fish that has spent some part of its life-cycle in an artificial environment and whose parents were spawned in an artificial environment.

Hatchery population - A population that depends on spawning, incubation, hatching or rearing in a hatchery or other artificial propagation facility.

Hazard - Hazards are undesirable events that a hatchery program is attempting to avoid.

Incidental take - The unintentional take of a listed species as a result of the conduct of an otherwise lawful activity.

Integrated harvest program - Project in which artificially propagated fish produced primarily for harvest are intended to spawn in the wild and are fully reproductively integrated with a particular natural population.

Integrated recovery program - An artificial propagation project primarily designed to aid in the recovery, conservation or reintroduction of particular natural population(s), and fish produced are intended to spawn in the wild or be genetically integrated with the targeted natural population(s). Sometimes referred to as “supplementation”.

Isolated harvest program - Project in which artificially propagated fish produced primarily for harvest are not intended to spawn in the wild or be genetically integrated with any specific natural population.

Isolated recovery program - An artificial propagation project primarily designed to aid in the recovery, conservation or reintroduction of particular natural population(s), but the fish produced are not intended to spawn in the wild or be genetically integrated with any specific natural population.

Mitigation - The use of artificial propagation to produce fish to replace or compensate for loss of fish or fish production capacity resulting from the permanent blockage or alteration of habitat by human activities.

Natural fish - A fish that has spent essentially all of its life-cycle in the wild and whose parents spawned in the wild. Synonymous with *natural origin recruit (NOR)*.

Natural origin recruit (NOR) - See *natural fish* .

Natural population - A population that is sustained by natural spawning and rearing in the natural habitat.

Population - A group of historically interbreeding salmonids of the same species of hatchery, natural, or unknown parentage that have developed a unique gene pool, that breed in approximately the same place and time, and whose progeny tend to return and breed in approximately the same place and time. They often, but not always, can be separated from another population by genotypic or demographic characteristics. This term is synonymous with stock.

Preservation (Conservation) - The use of artificial propagation to conserve genetic resources of a fish population at extremely low population abundance, and potential for extinction, using methods such as captive propagation and cryopreservation.

Research - The study of critical uncertainties regarding the application and effectiveness of artificial propagation for augmentation, mitigation, conservation, and restoration purposes, and identification of how to effectively use artificial propagation to address those purposes.

Restoration - The use of artificial propagation to hasten rebuilding or reintroduction of a fish population to harvestable levels in areas where there is low, or no natural production, but potential for increase or reintroduction exists because sufficient habitat for sustainable natural production exists or is being restored.

Stock - (see "Population").

Take - To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

Viable population threshold - An abundance level above which an independent Pacific salmonid population has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame.

**Attachment 2. Age class designations by fish size and species for salmonids released from hatchery facilities.**

(generally from Washington Department of Fish and Wildlife, November, 1999).

	SPECIES/AGE CLASS	Number of fish/pound	<u>SIZE CRITERIA</u> Grams/fish
X	Chinook Yearling	<=20	>=23
X	Chinook (Zero) Fingerling	>20 to 150	3 to <23
X	Chinook Fry	>150 to 900	0.5 to <3
X	Chinook Unfed Fry	>900	<0.5
X	Coho Yearling 1/	<20	>=23
X	Coho Fingerling	>20 to 200	2.3 to <23
X	Coho Fry	>200 to 900	0.5 to <2.3
X	Coho Unfed Fry	>900	<0.5
X	Chum Fed Fry	<=1000	>=0.45
X	Chum Unfed Fry	>1000	<0.45
X	Sockeye Yearling 2/	<=20	>=23
X	Sockeye Fingerling	>20 to 800	0.6 to <23
X	Sockeye Fall Releases	<150	>2.9
X	Sockeye Fry	> 800 to 1500	0.3 to <0.6
X	Sockeye Unfed Fry	>1500	<0.3
X	Pink Fed Fry	<=1000	>=0.45
X	Pink Unfed Fry	>1000	<0.45
X	Steelhead Smolt	<=10	>=45
X	Steelhead Yearling	<=20	>=23
X	Steelhead Fingerling	>20 to 150	3 to <23
X	Steelhead Fry	>150	<3
X	Cutthroat Trout Yearling	<=20	>=23
X	Cutthroat Trout Fingerling	>20 to 150	3 to <23
X	Cutthroat Trout Fry	>150	<3
X	Trout Legals	<=10	>=45
X	Trout Fry	>10	<45

1/ Coho yearlings defined as meeting size criteria and 1 year old at release, and released prior to June 1st.

2/ Sockeye yearlings defined as meeting size criteria and 1 year old.

The following is taken from: “[Narrative for proposal 199506325](#)”, the project proposal for this project in the 2007-2009 NPCC funding process. This document further describes many of the research, monitoring, and evaluation objectives and strategies for this project. It generally applies to Sections 1.10, 11, and 12 of the HGMP.

## **Appendix A: Quantitative Objectives and Monitoring and Evaluation Strategies for Yakima Basin Spring Chinook and Cle Elum Supplementation and Research Facility Activities**

### *Quantitative Objectives*

Tables A.1 and A.2 identify quantitative objectives for spring Chinook derived using general objectives stated in the Yakima Subbasin Plan (see Tables 3-22 of YSFWPB 2004b). Information and modeling work are still being developed to identify quantitative objectives for steelhead, fall Chinook, and coho. Table A.3 identifies containment objectives for non-target taxa of concern (NTTOC). Achievement of these objectives will be coordinated and managed by the Policy Group. The co-managers are committed to balancing the current and future benefits and costs of enhancing and restoring fish resources in the Yakima Basin. This includes enhancing and conserving habitat conditions for long-term benefits, exploiting increased harvest opportunities from supplementation, and containing undesirable genetic and ecological impacts. To this end, the co-managers have agreed to the following objectives and have committed to monitoring the results within an adaptive management framework.

As noted in the Management Plan Supplement (YSFWPB 2004b), the timeline for achieving many of the stated objectives in Tables 3-6 of the Supplement is 2020. However, many other objectives in these tables are longer term in nature and are not expected to be achieved until 2105. Achieving the objectives in tables 7-22 of the Supplement is dependent on stated contingencies such as resolution of funding, legal, and agency commitment issues. Similar contingencies apply to expected improvements in out-of-basin conditions relied on for assumed smolt-to-adult survival rates in Tables A.1 and A.2 below. Therefore, these contingencies are inherent in the performance periods shown in Tables A.1 and A.2.

Table A.1. Natural production and harvest objectives for *Upper Yakima Basin spring chinook salmon*. Values were estimated using the EDT and AHA models and are expressed as average annual abundances for different time strata under different harvest scenarios. Properly functioning conditions produce approximately 80% of historic conditions.

Goal and performance period	Habitat Condition	Natural Origin Upper Yakima Smolts at Chandler	Columbia River and Ocean Harvest (hatchery and natural origin fish)	Yakima Basin Harvest (hatchery and natural origin fish)	Natural Origin Adults at Roza
10 year goal (2003-2013 smolts; 2005-2015 adults)	Current Yakima Basin at capacity and 2.809% smolt to adult survival	134,411-142,216	1,777-2,590	1,031-1,854	2,268-3,014
20 year goal (2014-2024 smolts; 2016-2026 adults)	50% of properly functioning conditions in Yakima Basin and 4.50% smolt to adult survival	266,244-279,774	3,764-5,421	2,288-4,117	8,455-10,760
Long-term goal (>2024 smolts; >2026 adults)	100% properly functioning conditions in Yakima Basin and 8.05% smolt to adult survival	657,608-666,377	11,844-17,665	7,340-12,917	38,960-47,377



Table A.2. Natural production and harvest objectives for *Entire Yakima Basin spring chinook salmon*. Values were estimated using the EDT and AHA models and are expressed as average annual abundances for different time strata under different harvest scenarios. Properly functioning conditions produce approximately 80% of historic conditions.

Goal and performance period	Habitat Condition	Natural Origin Upper Yakima Smolts at Chandler	Columbia River and Ocean Harvest (hatchery and natural origin fish)	Yakima Basin Harvest (hatchery and natural origin fish)	Natural Origin Escapement
10 year goal (2003-2013 smolts; 2005-2015 adults)	Current Yakima Basin at capacity and 2.809% smolt to adult survival	183,450-196,045	1,996-2,879	1,184-2,117	3,321-4,393
20 year goal (2014-2024 smolts; 2016-2026 adults)	50% of properly functioning conditions in Yakima Basin and 4.50% smolt to adult survival	469,234-493,523	5,157-7,329	3,260-5,856	15,411-19,512
Long-term goal (>2024 smolts; >2026 adults)	100% properly functioning conditions in Yakima Basin and 8.05% smolt to adult survival	1,163,680-1,178,738	17,050-26,051	11,293-20,558	69,527-84,444

- Stray rates of Cle Elum Supplementation and Research Facility spring chinook salmon shall be < 5% of total hatchery production and < 5% of any natural spawning population besides the upper Yakima (e.g., Naches or American River stocks)

Table A.3. Containment objectives for non-target taxa of concern (NTTOC) in the Yakima Basin relative to supplementing the upper Yakima stock of spring chinook salmon. Objectives refer to negative impacts upon one or more of a taxas distribution, abundance or size structure relative to pre-supplementation levels.

NTTOC	Containment Objective
<b><i>Rare - species, stock, or regionally</i></b>	No impact
<ul style="list-style-type: none"> <li>Bull trout</li> <li>Pacific Lamprey</li> <li>Naches steelhead</li> <li>Satus steelhead</li> <li>Toppenish steelhead</li> <li>Upper Yakima steelhead</li> </ul>	Very low impact ( $\leq 5\%$ )
<b><i>Rare - in basin</i></b>	
<ul style="list-style-type: none"> <li>Marion Drain Fall chinook</li> <li>Mountain sucker</li> <li>Leopard dace</li> <li>Sand roller</li> </ul>	Low impact ( $\leq 10\%$ )
<b><i>Native game or food fish - very important</i></b>	
<ul style="list-style-type: none"> <li>Resident rainbow trout in the mainstem Yakima River</li> <li>Westslope cutthroat trout in the mainstem Yakima River</li> <li>Naches spring chinook salmon</li> <li>American River spring chinook salmon</li> </ul>	Moderate impact ( $\leq 40\%$ )
<b><i>Native game or food fish - important</i></b>	
<ul style="list-style-type: none"> <li>Mountain whitefish</li> <li>Resident rainbow trout in tributaries</li> <li>Westslope cutthroat trout in tributaries</li> </ul>	$\leq$ maximum impact that maintains all native species at sustainable levels
<b><i>Common</i></b>	
<ul style="list-style-type: none"> <li>Other native species</li> </ul>	

- Habitat conditions shall be enhanced to achieve the abundance goals and to meet properly functioning conditions.
- Science – Definitively (alpha  $\leq 0.05$  and beta  $\leq 0.10$ ) answer the following questions:
  - 1) Can integrated hatchery programs be used to increase long-term natural production?
  - 2) Can integrated hatchery programs limit genetic impacts to non-target chinook populations?
  - 3) Can integrated hatchery programs limit ecological impacts to non-target populations?
  - 4) Does supplementation increase harvest opportunities?

Answers to these and other related information will be disseminated to reach the broadest audience possible. This will include publication in peer reviewed journals, technical reports, and giving oral presentations. We will also provide access to raw data on the web.

*Biological Objectives, Tasks, and Methods*

Table A.4 describes biological objectives, work elements (tasks), and methods associated with this proposal. We also include rationale for each task and describe the relationship of each task to the regional monitoring framework (Appendix I of NPCC 2005). ISRP Review coincident with the first return of adult (4-year old) fish in 2001 raised concerns that the project was not sufficiently aggressive and rigorous in evaluating the domestication effects of supplementation. As a result of the ISRP review, the Project developed an expanded domestication monitoring plan which was first implemented in the fall of 2002. Given the importance of the domestication monitoring plan to the overall success of Project monitoring and evaluation efforts, the plan has been substantially updated and the most current version is included in its entirety at the end of this section.

The following list cross references the biological tasks in Table A.4 with the major species being studied in the Yakima Subbasin.

Spring Chinook: 1.a, 1.b, 1.c, 1.d, 1.e, 1.h, 1.i, 1.j, 1.k, 1.l, 1.m, 1.n, 1.o, 1.p, 2.a, 2.b, 3.a, 3.b, 4.a, 4.b, 4.c, 4.d

Fall Chinook: 1.a, 1.c, 1.e, 1.f, 1.h, 1.j, 1.m, 1.n, 1.o, 1.p, 2.a, 4.a, 4.b

Coho: 1.a, 1.c, 1.e, 1.g, 1.h, 1.i, 1.j, 1.l, 1.m, 1.n, 1.o, 1.p, 2.a, 4.a, 4.b

Steelhead: 1.a, 1.e, 1.h, 1.i, 1.j, 1.m, 1.n, 1.o, 2.a, 2.b, 4.a, 4.b

Note for biological objective 2 (Harvest monitoring) that monitoring of sport harvest of all species and in-basin tribal harvest of fall Chinook and coho is funded separately.

<b>Table A.4. Biological objectives, work elements (tasks), and methods.</b>	
<i>OBJ.</i>	Task, Hypothesis/Assumption, and Method
<b>1.</b>	<b>Objective: Natural Production:</b> Determine if supplementation and habitat actions increase natural production. Evaluate changes in natural production with specified statistical power.
<b>1.a</b>	<b>Task:</b> Modeling: Design complementary supplementation/habitat enhancement programs for coho, spring &

	<p>fall chinook &amp; steelhead in the Yakima and Klickitat Subbasins.</p> <p><b>Hypothesis:</b> Ecosystem Diagnosis and Treatment and All H's Analyzer (AHA) computer modeling can integrate habitat quantity, quality, and life history data to evaluate alternative enhancement strategies with sufficient accuracy to facilitate decision-making. Modeling and statistical analysis (e.g. power analysis) can continue to be used throughout the Project to evaluate reproductive success study designs, domestication study designs, treatment and control experimental designs, etc.</p> <p><b>Rationale:</b> The EDT and AHA models are currently the major tools for design and adaptive management of enhancement projects for species and stocks in the Yakima and Klickitat Subbasins. Output from these models is considered to be very valuable in a relative sense: for evaluating the relative benefits of alternative enhancement actions and especially for discovering hidden synergism among a series of individual actions (e.g., supplementation and specific habitat restoration actions). These models are valuable for their ability to synthesize what is known about a population and its habitat to generate testable hypotheses. The linkage between effect and cause is explicit throughout, and therefore amenable to test and revision. Moreover, this explicit linkage facilitates monitoring programs for enhancement actions based on the EDT diagnoses. Critical environmental parameters (L<sub>2</sub>'s) in critical reaches in which remedial actions are taken are identified, facilitating effectiveness monitoring. Validation monitoring – determining whether the target population responds as predicted – is also clearly defined, down to the level of the specific life stage for which the actions are presumed to be most beneficial. It was with the preceding thoughts in mind that the current Yakima coho and fall chinook programs, and the entirety of the current Klickitat program were developed. Each generates specific information on habitat quality and quantity and/or population performance that can easily be incorporated into the EDT model and evaluated.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Action Effectiveness: What actions are most effective at addressing the limiting factors preventing achievement of habitat, fish or wildlife performance objectives?</p> <p><b>Methods:</b> To diagnose the fundamental environmental factors limiting natural production, and to estimate relative improvements in production attributable to alternative enhancement strategies, by using the “Ecosystem Diagnosis and Treatment” (EDT) model. Continue to model statistical power associated with proposed monitoring plans such as reproductive success, genetic risk assessment, adult sub-sampling frequency, etc.</p>
<p><b>1.b</b></p>	<p><b>Task:</b> Percent habitat saturation and limiting factors: Determine the annual percentage of habitat saturated by upper Yakima spring chinook parr and whether food or space restrict production of upper Yakima spring chinook smolts.</p> <p><b>Hypotheses:</b>  Ho: Distribution, abundance, and size of parr will not significantly increase in the upper mainstem Yakima River (Ho<sub>1</sub>), or its tributaries (Ho<sub>2</sub>), during supplementation.  Ho: Competition for space (Ho<sub>1</sub>), or food (Ho<sub>2</sub>), will not significantly impact the growth and survival of juvenile spring chinook, and ultimately limit supplementation success.</p> <p><b>Rationale:</b> Even if supplementation produced smolts and adults identical to wild fish in every way, project success could be limited if existing production actually represented the carrying capacity of the Yakima Subbasin. The long-term mean annual abundance of parr may increase because supplementation has the potential to fill the environment to capacity every year. Space and food competition can limit upper Yakima spring chinook production. For example, the distribution of parr has not increased substantially despite having an increase in the number of spawners. Space and or food may be abundant in the Yakima River, but if they are biologically unavailable (e.g., flows are too fast) then they won't benefit fish. Yakima River flows are managed by the Bureau of Reclamation and are abnormally high during the summer and abnormally low during winter months. Knowing what factors currently limit the capacity of the environment can help to interpret interannual variation in survival and focus habitat actions on increasing capacity.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Uncertainties Research: What are the competitive impacts of hatchery and wild fish in a system? Is competition between hatchery and wild fish a source of mortality for wild stocks in the Columbia Basin?</p> <p><b>Methods:</b> Percent habitat saturation will be evaluated by comparing the abundance of yearly spawners or spring chinook parr to indices of growth and survival. The ratio of spring chinook parr in a given year per the</p>

	<p>number of redds counted in the previous year will be used as an index of survival, while spring chinook parr size in the fall will be used as an index of growth. Parr abundance and size data will be collected by backpack and drift boat electrofishing within index sites of the mainstem Yakima River and its tributaries. Stomach contents of spring chinook parr will be collected during the summer and fall, in three index areas, over time, in order to assess the importance of food limitation in the upper Yakima River. The food and chinook abundance data will be used to calculate an index of total food consumed by the population. In order to determine the amount and percentage of area within the mainstem that spring chinook may occupy, water velocities and depths will be measured along transects and the values compared to those collected where spring chinook were present (microhabitat measurements). In those areas that meet the necessary flow conditions for chinook salmon, more detailed measurements will be taken to help assess the amount of habitable area that meet the conditions for survival.</p> <p>Spring chinook microhabitat will be measured in the mainstem of the Yakima River by snorkeling and marking the location of spring chinook present. Physical parameters will then be measured at and around the observed focal point of the spring chinook at each marked location. Spring chinook territory size will also be measured in order to determine the number of locations within bioavailable area that may be occupied. Invertebrate mass at differing flows will be measured in order to determine whether or not sufficient food is available in areas that, due to high flow, are not bioavailable to spring chinook.</p>
<p><b>1.c</b></p>	<p><b>Task:</b> Hatchery spring chinook juvenile marking: Estimate hatchery spring chinook smolt survival to Chandler &amp; mainstem dams using PIT-tags, and smolt-to-adult survival (release to Yakima mouth) using CWTs and elastomer marks. This task includes fin-clipping and coded-wire tagging of juvenile fall chinook and coho. A portion of coho releases are PIT-tagged for juvenile survival studies.</p> <p><b>Hypothesis:</b> <math>H_0</math>: Survival of treatment fish does not exceed survival of control fish. Current release numbers of juvenile spring chinook assume that control smolt-to-adult survival rates will be 0.2% or higher. Under these circumstances it will be possible to detect a 50% effect size with 90% probability, <math>\alpha = 10\%</math>.</p> <p><b>Rationale:</b> For spring chinook, evaluate hatchery treatments in terms of relative smolt survival to Chandler, McNary and John Day using PIT tags, and relative smolt-to-adult survival (to Roza Dam) using snout-placed CWT's, and colored elastomer in the adipose eye-lid to denote treatment replicates. For coho, evaluate survival to Chandler and McNary using PIT tags and evaluate relative smolt-to-adult (Chandler smolt to Prosser adult) survival of hatchery-origin (marked) versus natural-origin (unmarked) fish. Fall Chinook marking is used to evaluate relative survival between different acclimation sites and for monitoring status of the overall population.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Action Effectiveness</p> <p><b>Methods:</b> To estimate differences in smolt survival by treatment/control, acclimation site, and raceway, we will PIT-tag, adipose-clip, CWT (snout) 40,000 parr, enough to detect survival differences to McNary Dam with specified power (<math>\alpha=.05</math> <math>\beta=.1</math>, effect size=50%). The remainder of the spring Chinook annual release will be adipose-clipped and CWT'ed in the snout, and elastomer-eye tagged to uniquely identify treatment, acclimation site, and raceway. All coho will be marked in some manner to allow distinction of hatchery- and natural-origin adult returns at Prosser. Fall chinook will be marked to the extent that funding allows. Returning spring Chinook adults will be interrogated at Roza using hand-held CWT detectors and UV lights (for elastomer detection) to determine smolt-to-adult survival by group, and will then be released to spawn. CWT'ed fish will be recovered in fisheries (tasks 2.a and 2.b) and spawning ground surveys (task 1.j). Statistical analysis by ANOVA.</p>
<p><b>1.d</b></p>	<p><b>Task:</b> Roza juvenile wild/hatchery smolt PIT tagging: Capture, PIT-tag and release wild and hatchery spring Chinook to estimate relative wild/hatchery smolt survival to Chandler and the McNary Dam.</p> <p><b>Hypotheses:</b> <math>H_{0,1}</math>: There is no difference in Roza-to-Chandler survival between CESRF treatment smolts and wild upper Yakima smolts.  <math>H_{0,2}</math>: There is no difference in Roza-to-McNary survival between CESRF treatment smolts and wild upper Yakima smolts.  <math>H_{0,3}</math>: There is no difference in Roza-to-Chandler survival between CESRF control smolts and wild upper Yakima smolts.  <math>H_{0,4}</math>: There is no difference in Roza-to-McNary survival between CESRF control smolts and wild upper Yakima smolts.  <math>H_{0,5}</math>: There is no difference in Roza-to-Chandler survival between CESRF control and treatment smolts.  <math>H_{0,6}</math>: There is no difference in Roza-to-McNary survival between CESRF control and treatment smolts.</p> <p><b>Rationale:</b> Relative hatchery/wild smolt survival to Chandler and McNary is a critical mechanistic element</p>

	<p>of project evaluation.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends, Action Effectiveness</p> <p><b>Methods:</b> Roza Canal fish bypass will be used to capture wild and hatchery spring chinook smolts, which will be PIT-tagged and released on site. Analysis by binomial techniques.</p>
1.e	<p><b>Task:</b> Wild/hatchery survival and enumeration (Chandler Juvenile Monitoring Facility): Refine operational and analytical procedures used in estimating hatchery and wild smolt passage at Chandler smolt trap by stock.</p> <p><b>Hypothesis:</b> There is no meaningful fisheries-related experimental hypothesis associated with this task. There is, however, a justified belief that smolt production can be estimated at Chandler by describing the relationship between smolt entrainment (E) and the percent discharge diverted into Chandler Canal (PDD), and by determining the factors that control canal survival (Sc) and the true sampling rate (R) inside the trap:</p> <p>Daily Passage = (Daily Catch) / (E*Sc*R) and</p> $Seasonal Passage = \sum_{days\ in\ season} Daily Passage$ <p>Similarly, there is no meaningful fisheries-related experimental hypothesis related to the secondary task of determining the stock composition of smolts by time stratum by means of DNA micro satellite techniques.</p> <p><b>Rationale: 1.)</b> As referenced in the Spring Chinook Monitoring Plan, (Busack et al. 1997), Chandler is an essential element of M&amp;E for Yakima stocks. Information wholly or partly collected at Chandler includes annual smolt production and outmigration timing, egg-to-smolt and smolt-to-adult survival rates, and relative smolt survival rates (to Chandler) between hatchery control and treatment groups and between hatchery groups and marked groups of wild smolts. This information is used to determine whether post-supplementation changes in production and survival rates are consistent with a population for which natural production is increasing. This data can be gathered for all anadromous salmonids within the basin and is stock-specific for spring chinook (using satellite DNA analysis). <b>2.)</b> To refine smolt passage estimates (future and historical) by increasing the precision of passage estimators and correcting for any bias associated with the estimators.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends: What is the freshwater productivity of Yakima river salmon populations?</p> <p><b>Methods: 1.)</b> Chandler is operated continuously except for brief periods of canal maintenance. Species-specific relationships between canal diversion and smolt entrainment rates have been developed, and daily passage is estimated as the ratio of raw catch to entrainment (total production is the sum over the season). A subsample of smolts is bio-sampled each day and all PIT-tagged fish are interrogated as they enter the facility. Smolt-to-adult survival for wild fish is estimated as the ratio of brood year returns to brood year smolt production. Brood year returns are estimated (for example) for spring chinook as the sum of the number of jacks the year after outmigration, the number of age 4 fish two years after outmigration, and so on. Annual age composition is estimated by analyzing scales from spawning ground carcasses and adults sampled at the Roza adult monitoring facility, and total returns are estimated as the sum of Prosser counts and below-Prosser harvest. Microsatellite DNA is taken from a subsample of all spring Chinook entrained in the Chandler facility on a daily basis to determine stock composition (American, Naches, Upper Yakima). <b>2.)</b> Replicated releases of PIT-tagged smolts are used to make a series of entrainment rate estimates. Logistic regression is then used to express entrainment as a function of one or more hydraulic variables (e.g., percent discharge diverted into the canal) characterizing flow conditions at Prosser Dam at the time of release. These flow/entrainment relationships will be used to estimate future smolt production, to revise historical estimates of smolt production, and to generate confidence intervals for both.</p>
1.f	<p><b>Task:</b> Fall chinook survival study: Determine optimal locations within the lower Yakima Basin for increasing natural production of fall chinook, and to guide location of future acclimation/release sites.</p> <p><b>Hypothesis:</b> H<sub>0</sub> : The survival of subyearling chinook is equal for fish originating from three reaches in the Yakima River. The three reaches of interest are Above Prosser, Mabton-to-Horn Rapids, and Horn Rapids-to-delta.</p> <p>H<sub>0</sub> : Water temperature above Prosser Dam limits juvenile chinook growth and that later emergence and slower growth limits survival of fish produced above Prosser Dam relative to subyearling chinook in the lower two reaches.</p> <p><b>Rationale:</b> Previous modeling of subyearling chinook growth and survival in the lower Yakima River</p>

	<p>suggests that juvenile survival through the lower Yakima River may be higher for the lowermost portions of the mainstem (Mabton-to-Horn and Horn-to-delta reaches), and that smolt-to-smolt survival is perhaps the major limitation on natural production in the Yakima.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Uncertainties research: Is the habitat capable of supporting salmonids at levels of survival that will bring about restoration?</p> <p><b>Methods:</b> Beach seining for wild juvenile fall Chinook was initiated in 2001. In April of 2004, beach seine sites were established at Richland, Granger and Union Gap to target wild juvenile fall Chinook for growth profiling and marking via Passive Integrated Transponder (PIT) tag or caudal clip. Temperature thermographs are located in each of the three reaches to evaluate the relationship between temperature and growth.</p>
1.g	<p><b>Task:</b> Attempt to establish naturally producing coho populations in the upper and lower Yakima River and its tributaries and in the Naches River and its tributaries. Continue to investigate the coho life history in the Yakima Basin. Assess ecological interactions (see tasks under Objective 4). Develop and test use of additional culturing, acclimation, and monitoring sites.</p> <p><b>Hypothesis:</b> The survival of a suitable stock of hatchery-origin coho can be increased to levels sufficient to establish a naturalized population.</p> <p><b>Rationale:</b> By the middle 1980s, coho were extirpated from the Yakima Basin and large portions of the middle and upper Columbia River Basins. This project is attempting to restore some of this loss pursuant to mitigation and treaty trust obligations embodied in the NPCC FWP and <i>U.S. v Oregon</i> agreements. Questions regarding rates of naturalization for hatchery-origin fish allowed to spawn in the wild and integration of hatchery and natural populations have been identified as high priority research needs by the NPCC. Restoration of coho salmon to the Yakima Basin and other middle and upper Columbia River Basins is also consistent with stated ecosystem restoration goals in the FWP and subbasin plans. Monitoring and evaluation results will facilitate decision making regarding long-term facility needs for coho.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Uncertainties research: What are the range, magnitude, and rates of increase of natural spawning fitness when hatchery-origin fish are outplanted to native habitats from which they were extirpated? Is it possible to integrate natural and artificial production systems in the same basin to achieve sustainable long-term productivity?</p> <p><b>Methods:</b> Implementation plans and guidance for phase II of the coho feasibility study are documented in the coho master plan (Hubble et al 2004). The design of the coho optimal stock has evolved toward testing survival from specific acclimation sites (including the current four), and trying to keep locally collected broodstock (Yakima Stock) acclimating in Lost Creek (Naches) and Boone Pond (Upper Yakima) in the upper portions of both watersheds. In this design, acclimation sites can only be compared geographically across sub-basins (Yakima and Naches). Out-of-basin coho will be acclimated at downstream acclimation sites in both sub-basins. A minimum of 2,500 pit tags will represent each acclimation site during the normal acclimation period of February through May. Releases will continue to be volitional beginning the first Monday of April. An additional 3,000 PIT-tagged coho will be planted into each acclimation site during late summer to assess and monitor over-winter acclimation and survival. Acclimation sites will have PIT tag detectors to evaluate fish movement during the late winter and early spring.</p>
1.h	<p><b>Task:</b> Adult salmonid enumeration and bio-sampling at Prosser Dam: Estimate the total number of adult salmonids returning to the Yakima Basin by species (spring and fall chinook, coho and steelhead).</p> <p><b>Hypothesis:</b> Adult salmonid populations will not increase due to supplementation.</p> <p><b>Rationale:</b> Adult salmonid enumeration is a critical mechanistic element of project evaluation.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends: Size and growth rate of adult salmonid populations; Action Effectiveness</p> <p><b>Methods:</b> Use time-lapse video recorders (VHS) and cameras in viewing windows in all ladders at Prosser Dam to monitor adult passage for all species year-round. Video tapes are read and interpreted manually to count fish passage by species. Data are entered into a Microsoft Access database. After quality control, daily dam counts are uploaded to DART and reports are posted on the ykfp.org web site. In the fall all fish passing upstream via the Prosser Denil ladder and trap are anesthetized and bio-data are collected (lengths, weights, scales, and DNA); a portion of fall chinook and coho are taken for broodstock; and a portion of fish are also radio-tagged.</p>
1.i	<p><b>Task:</b> Adult salmonid enumeration, bio-sampling and broodstock collection at Roza and Cowiche dams. Estimate the total number of adult salmonids returning to the upper Yakima (Roza) and Naches (Cowiche).</p>

	<p><b>Hypothesis:</b> Adult salmonid populations will not increase due to supplementation.</p> <p><b>Rationale:</b> Adult salmonid enumeration is a critical mechanistic element of project evaluation.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends: Size and growth rate of adult salmonid populations; Action Effectiveness</p> <p><b>Methods:</b> From approximately September 15 to December 15 monitor passage videographically. Otherwise, estimate passage of all adult salmonids and collect spring Chinook broodstock by operating the adult trap. This task also includes bio-sampling of spring Chinook and steelhead at Roza dam and mark sampling to estimate return of hatchery-origin spring Chinook by experimental group (treatment\acclimation site\raceway). All CWT'ed spring Chinook will be diverted to a holding tank, interrogated for elastomer marks and internal marks using hand-held CWT and PIT-tag detectors.</p>
1.j	<p><b>Task:</b> Spawning ground surveys (redd counts): Monitor spatial and temporal redd distribution in the Yakima Subbasin (spring chinook, Marion Drain fall chinook, coho, Satus/Toppenish steelhead), and collect carcass data.</p> <p><b>Hypothesis:</b> Redd counts accurately reflect potential egg deposition and age distribution from carcass recovery can be used to estimate age structure. There is currently no central YKFP hypothesis tested by spawner surveys directly, although the information gathered by spawner surveys is definitely relevant to a number of issues important to the YKFP. Examples of such issues for the upper Yakima spring chinook program include:</p> <p>H<sub>0</sub>: there is no difference among CESRF control, treatment and wild fish in mean spawn timing</p> <p>H<sub>0</sub>: there is no difference between Easton, Clark Flat and Jack Creek spawners in the geographic distribution of spawning sites</p> <p>H<sub>0</sub>: there is no difference in egg retention rates among CESRF control, treatment and wild spawners</p> <p>H<sub>0</sub>: there is no difference among CESRF control, treatment or wild upper Yakima spring chinook in spawners/redd, where “spawners” is the number of fish passed above the trap at Roza.</p> <p>These and a great many other hypotheses <i>might</i> become critical in the future, but there is no reason to elevate their importance now. Spawner survey data bearing on these issues will be routinely collected as an element of basic fisheries management. If a particular concern arises, it will be addressed explicitly.</p> <p><b>Rationale:</b> Spawning ground surveys are a critical mechanistic element of project evaluation.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends: Distribution of adult salmonid populations; Action Effectiveness</p> <p><b>Methods:</b> Weekly foot and/or boat surveys are conducted within the geographic range for each species (increasing for Yakima coho as acclimation sites are relocated upriver and returns increase). Redds are individually marked during each survey and carcasses are sampled for marks and to collect data on egg retention, age (analysis of scale samples), sex, and length. Comprehensive spring chinook and steelhead (in Satus, Toppenish, and Ahtanum Creeks) spawning surveys are conducted annually. These are complete surveys, covering the entire spawning area, not just index sites. They are also multiple surveys, usually with peak counts and counts for several weeks preceding and following the peak. Although substantial effort is applied to obtain comprehensive spawning ground survey data for fall chinook and coho, annual variability in water conditions can preclude complete surveys.</p>
1.k	<p><b>Task:</b> Yakima spring chinook residual and precocity studies: Monitor abundance, distribution, and behavior of wild and hatchery residual and precociously mature spring chinook salmon.</p> <p><b>Hypothesis:</b> Ho: Supplementation does not significantly change the abundance, distribution, or behavior of residual or precocious male spring chinook.</p> <p><b>Rationale:</b> The CESRF may alter the abundance, distribution, and behavior of precocious males, which could influence naturally produced offspring. Large numbers of residuals could also negatively impact other species through increased competition for available food and space or through increased predation.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Uncertainties Research: Do differing hatchery-rearing methods lead to different physiology, behavior, and life history patterns of hatchery products when contrasted to natural populations?</p>



	<p><b>Methods:</b> In order to assess supplementation-induced changes in abundance, counts of precocious spring chinook present on active redds will be made within 100 river kilometers of the upper Yakima River basin, which constitutes more than 99 percent of the area in which redds are found annually in the Upper Yakima River. A sample of observed precocious males will be captured and examined for sexual maturity through examination of the gonads, and scales collected for aging. In order to determine factors that play a role in dominance among precocious male spring chinook on the redds, behavioral observations of precocious spring chinook will be made while snorkeling active redds in the mainstem Yakima River. Snorkelers will observe and record agonistic interactions between precocious male chinook of differing size, age, and origin. The abundance and distribution of precocious male spring chinook not on redds will be determined by drift boat electrofishing in index areas of the mainstem Yakima River. Lastly, the abundance and distribution of juvenile chinook that did not migrate as age 1+ smolts (residuals) will be assessed by counts made while snorkeling 31.5 river kilometers in the mainstem Yakima river in the spring and summer months. A portion of observed residuals will also be evaluated for sexual maturity and age. Temporal abundance and distribution of hatchery residuals will be determined by snorkeling index sites within a tributary of the Yakima River that contains a hatchery acclimation site.</p>
<p><b>1.l</b></p>	<p><b>Task:</b> Relative hatchery/wild reproductive success: Determine whether spawning behavioral and reproductive success of wild and hatchery-origin spring chinook are comparable (see task 3.a Domestication), and estimate reproductive success of hatchery coho in a natural stream.</p> <p><b>Hypothesis: Coho:</b> Ho: Reproductive success of hatchery coho spawning in certain areas of the Yakima Subbasin is high enough to support a naturalized population.</p> <p><b>Rationale:</b> The reproductive competence of hatchery-reared adults is a major uncertainty surrounding supplementation.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Uncertainties Research: What are the range, magnitude, and rates of deterioration of natural spawning fitness of integrated (supplemented) populations? Is it possible to integrate natural and artificial production systems in the same basin to achieve sustainable long-term productivity?</p> <p><b>Methods: Coho:</b> We will identify optimal reaches and tributaries for natural coho production, and for future acclimation/release sites, by comparing existing, tributary- and reach-specific substrate composition data with coho reproductive performance under controlled conditions. Controlled matings will be conducted in a semi-natural channel not subject to extreme flow fluctuations. This channel will be sub-divided into segments with substrate composed of various proportions of fine particles. Groups of hatchery coho will be allowed to spawn in each segment. Weirs will be installed between segments in order to capture emergent fry, and mean egg-to-fry survival will be estimated for each segment. Observed egg-to-fry survival rates will be compared to expected rates for wild coho in order to assess the bias attributable to hatchery ancestry of the donor stock. Bias adjusted relationships between percent fines and egg-to-fry survival will then be applied to the existing data for potential coho spawning areas throughout the basin. Estimated egg-to-fry survival values for potential spawning areas will be incorporated into the EDT model to identify the most promising areas for coho re-introduction, and for locating future acclimation/release facilities.</p>
<p><b>1.m</b></p>	<p><b>Task:</b> Scale analysis: Determine age and stock composition of juvenile and adult salmonid stocks and predator species in the Yakima basin.</p> <p><b>Hypothesis:</b> Scale samples can be used to reliably determine the age of fish. Naturalized coho can reliably be distinguished from hatchery coho using scale analysis.</p> <p><b>Rationale: 1. Spring chinook.</b> To determine age and stock composition of juvenile and adult salmonid stocks in the Yakima Subbasin. Age structure of naturally produced upper Yakima spring chinook will be monitored to ensure that the age structure does not change as the result of supplementation. See also task 3.a Domestication.</p> <p><b>2. Coho.</b> So long as it is feasible to mark 100% of the hatchery coho, scale analysis to determine origin type will be unnecessary. We expect to mark 100% of all hatchery coho released in the Yakima. However, continued funding for 100% marking of coho is not certain. It is therefore prudent to develop techniques using scale analysis to differentiate between hatchery and wild origin coho.</p> <p><b>3. Yakima River Predators.</b> Potential predator fish control projects are likely to be more feasible when most of the predatory impact is confined to several older age classes. We are collecting this information against the possibility of a need to implement a predator control program in the future.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends: What is the age structure of Yakima River salmonid populations?</p>

	<p><b>Methods: 1. Spring Chinook:</b> We will determine age distribution by scale analysis. See also task 3.a Domestication. <b>2. Coho:</b> We will use scale analysis to determine the proportion of hatchery vs. wild smolt and adult Yakima coho production. Juvenile coho scales will be randomly collected at Chandler. Estimates of the proportion of hatchery and wild smolts will be applied to the estimated smolt out migration. Adult coho scales will be collected at the broodstock collection facilities to estimate the proportion of hatchery/wild escapement. Estimates of the proportion of hatchery and wild adults will be applied to estimated adult returns. <b>3. Yakima River Predators:</b> Collect scale samples from piscivorous fishes collected while performing task 4.b (See below).</p> <p>The two scale readers involved with aging scales are involved in quality control programs utilizing known age scales and a second reader confirmation. Both readers have aged thousands of Columbia and Snake river spring chinook scales annually over the past 15-20 years. There are known-age hatchery fish of all species within these samples marked with CWTs or PIT tags allowing verification of ages. We will also be collecting known-age scales from both hatchery and wild adults marked as juveniles that will allow us to verify age designations. Finally, the two project scale readers exchange all aged scales and independently age them. They then reach consensus on any differences in age designations.</p>
1.n	<p><b>Task:</b> Habitat inventory, aerial videos and ground truthing: Measure critical environmental variables by analyzing data extracted from aerial videos and verified by ground observations.</p> <p><b>Hypothesis:</b> A significant proportion of the inter-annual variability in salmon and steelhead productivity is attributable to fluctuations in key environmental factors inside the subbasin that can be monitored.</p> <p><b>Rationale:</b> These data are critical to validating EDT and AHA model outputs which are used to guide Project decisions.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends; Action Effectiveness</p> <p><b>Methods:</b> Aerial videos of the Yakima Subbasin will be conducted and analyzed. The habitat conditions (e.g. area of “watered” side channels, LWD, pool/riffle ratio, etc.) from the videos will be checked by dispatching technicians to specific areas to verify that conditions are in fact as they appear on video.</p>
1.o	<p><b>Task:</b> Sediment impacts on habitat: Monitor stream sediment loads associated with the operation of dams and other anthropogenic factors (e.g., logging, agriculture and road building) affecting streams in the Yakima Subbasin. This task is cost-shared with the USFS.</p> <p><b>Hypothesis:</b> Salmon and steelhead production can be limited by anthropogenic sediment loading. This task does not address a central experimental hypothesis of the upper Yakima spring chinook supplementation program. Rather, it is actually an element of our basic fisheries monitoring/management program, much like the spawner surveys, video-based escapement monitoring at Prosser, Roza and Cowiche Dams, and so on.</p> <p><b>Rationale:</b> Excessive sediment loads can play a critical role in egg-to-fry survival, and can depress survival and productivity of many other life stages of salmonids. The task actually amounts to regular substrate sampling in the upper Yakima, above and below historical points of sediment loading (e.g., below Easton Dam and Lake Easton, where regular fall maintenance of the control structures at the dam calls for lake draw-down, which is sometimes accompanied by heavy rainfall and mobilization of fine sediment, which is deposited on the critical spawning areas in the Easton reach). It provides fundamental ecological information for the refinement of our understanding of limiting factors for upper Yakima anadromous salmonids. These data provide input to the EDT and AHA models.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends</p> <p><b>Methods:</b> Representative gravel samples will be collected from throughout an impacted reach. Each sample will be analyzed to estimate the percentage of fines or small particles present. The state TFW program guidelines on sediments will then be used to specify the impacts estimated sedimentation levels have had on salmonid egg-to-smolt survival. These impacts would be incorporated in analyses of impacts of “extrinsic” factors on natural production.</p>
1.p	<p><b>Task:</b> Biometrical support: Provide the services of a half- time PH.D. level biometrician for the project.</p>
2.	<p><b>Objective: Harvest:</b> Monitor and evaluate changes in harvest of YKFP targeted stocks.</p>
2.a	<p><b>Task:</b> Out-of-basin harvest monitoring: Estimate harvest of hatchery- and natural-origin anadromous salmonids outside of the Yakima Subbasin.</p> <p><b>Hypothesis:</b> H<sub>0</sub>: Supplementation will not increase out-of-basin harvest.</p> <p><b>Rationale:</b> Harvest monitoring is a critical element of project evaluation. Harvest data are also important for deriving overall smolt-to-adult survival estimates of hatchery- and natural-origin fish.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends; Action Effectiveness</p>

	<p><b>Methods:</b> Monitor recoveries of CWTs and PIT tags in out-of-basin fisheries using queries of regional RMIS and PTAGIS databases. Coordinate with agencies responsible for harvest management (WDFW, ODFW, USFWS, CRITFC, etc.) to estimate the harvest of target stocks.</p>
2.b	<p><b>Task:</b> In-basin harvest: Estimate harvest of hatchery- and natural-origin anadromous salmonids within the Yakima Subbasin.</p> <p><b>Hypothesis:</b> H<sub>0</sub>: Supplementation will not increase harvest in the Yakima Subbasin.</p> <p><b>Rationale:</b> Harvest monitoring is a critical element of project evaluation. Harvest data are also important for deriving overall smolt-to-adult survival estimates of hatchery- and natural-origin fish.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends; Action Effectiveness</p> <p><b>Methods:</b> Monitor tribal subsistence and sport fisheries on the Yakima rivers at designated locations. Fish will be interrogated for various marks. This information will be used along with other adult contribution data (i.e. broodstock, dam counts, spawner ground surveys) to determine overall project success.</p>
3.	<p><b>Objective: Genetics:</b> Monitor and evaluate genetic change due to domestication and potential genetic change due to in-basin and out-of-basin stray rates.</p>
3.a	<p><b>Task:</b> Yakima spring chinook domestication. A comprehensive domestication monitoring plan has been developed and is underway for Upper Yakima spring chinook (see Appendix A at the end of Section F). The performance of the supplemented Upper Yakima spring chinook population (100% natural-origin broodstock), is compared to the performance of an Upper Yakima control line maintained under a regime of continuous hatchery culture, and to an unsupplemented wild control line in the neighboring Naches River. Performance is measured at 14 adult and 15 juvenile traits that encompass virtually the entire range of domestication impacts noted in the literature. The plan covers as well two key features of supplementation success articulated by the ISAB and ISRP (2005): recruits per naturally spawning female, and target population natural replacement rate. Details on individual traits are presented in Appendix A at the end of section F.</p> <p><b>Hypotheses:</b> The three-line design with controls at both ends of the domestication spectrum allow two major null hypotheses: 1- Domestication does not occur under supplementation (comparison of S and WC lines); and 2- Domestication under supplementation occurs at the same rate as in a situation of pure hatchery culture. Null hypotheses for the two additional supplementation success items are: 3- Recruits per naturally spawning female (corrected for density) do not decrease over time; and 4- Reproductive success of naturally spawning natural-origin and hatchery-origin fish are the same. Specific hypotheses for each trait to be monitored are detailed in Appendix A.</p> <p><b>Rationale:</b> The NPCC’s draft Columbia Basin Research Plan (NPCC 2005) identified the following critical management uncertainty with respect to hatcheries:</p> <p><i>1. What are the range, magnitude, and rates of deterioration of natural spawning fitness of integrated (supplemented) populations and the relationship of the deterioration with management rules, including the proportion of hatchery fish permitted on the spawning grounds, the broodstock mining rate, and the proportion of natural origin adults in the hatchery broodstock is undetermined?</i> This uncertainty is restated in Appendix C of the draft research plan as “Determine the rate of domestication and re-naturalization of hatchery salmon populations”. In part IV of the draft research plan, this uncertainty is listed as the number 1 research priority for the FWP.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Uncertainties Research: What are the range, magnitude, and rates of deterioration of natural spawning fitness of integrated (supplemented) populations? Is it possible to integrate natural and artificial production systems in the same basin to achieve sustainable long-term productivity?</p> <p><b>Methods:</b> A detailed description of monitoring methods by trait is provided in Appendix A at the end of section F.</p>
3.b	<p><b>Task:</b> Stray recovery on Naches and American spawning grounds: Determine the extent of straying from the supplemented Upper Yakima stock into the Naches and American River stocks and to out-of-basin areas.</p> <p><b>Hypothesis:</b> Spawning ground recovery of strays will be complete enough to support estimation of maximum levels of stray rates with specified precision.</p> <p><b>Rationale:</b> The literature and scientific reviews recommend monitoring of stray rates to determine impacts from supplementation programs.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Uncertainties Research: At what level does non-local origin straying, and interbreeding become a problem for natural spawning local stocks?</p>

	<p><b>Methods:</b> Upper Yakima fish on the American and Naches spawning grounds will be counted during normal spawning ground surveys and compared to the total run to estimate the maximum rate of straying. In addition, PTAGIS and RMIS queries will be run periodically to monitor out-of-basin stray rates based on recoveries of PIT and CWT tags in other subbasins.</p>
<b>4.</b>	<p><b>Objective: Ecological Interactions:</b> Monitor and evaluate ecological impacts of supplementation on non-target taxa, and impacts of strong interactor taxa on productivity of targeted stocks.</p>
<b>4.a</b>	<p><b>Task:</b> Avian predation index: Monitor, evaluate, and index the impact of avian predation on annual salmon and steelhead smolt production in the Yakima Subbasin.</p> <p><b>Hypothesis:</b> Ho: Avian predators will not significantly impact the survival of juvenile spring Chinook salmon, nor ultimately limit the success of supplementation.</p> <p><b>Rationale:</b> Avian predators are capable of significantly depressing smolt production and accurate methods of indexing avian predation across years have been developed. The loss of wild spring Chinook salmon juveniles to various types of avian predators has long been suspected as a significant constraint on production and could limit the success of supplementation. The index consists of two main components: 1) an index of bird abundance along sample reaches of the Yakima River and 2) an index of consumption along both sample reaches and at key dam and bypass locations (called hotspots). Due to a major shift in the major avian predator, first observed in 2003, from Ring-Billed and California Gulls (<i>Larus delawarensis</i> and <i>L. californicus</i>) to American White Pelican (<i>Pelecanus erythrorhynchos</i>) in the lower Yakima River, changes in piscivorous predation have occurred and warrant further study to quantify consumption rates of salmonids and other preferred prey species.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends; Action Effectiveness: What is the effect of management alternatives / actions used to reduce the impact of avian predators?</p> <p><b>Methods:</b> Abundance and consumption indexes will be calculated for each major bird predator. Methods to determine the feasibility of accomplishing these two components will be tested. Piscivorous birds will be counted using an inflatable raft, driftboat, or jetsled depending upon water conditions. Aerial surveys may also be conducted over the Yakima River between March and September to further assess abundance and distribution of pelicans, gulls and other large predatory birds. Shortly after or during bird censuses a consumption index will be developed. Consumption by gulls and pelicans at hotspots will be based on direct observations of foraging success and modeled abundance while consumption by all other piscivorous birds will be estimated using published dietary requirements and modeled abundance. Seasonal patterns of avian piscivore abundance will be identified, diurnal patterns of gull and pelican abundance at hotspots will be identified, and predation indices calculated for river reaches and hotspots for the spring and summer. Observational and direct methods will be attempted to determine which methods are most appropriate for pelicans, gulls and other major fish predators. The project intends to trap, radio tag, wing tag, and do periodic stomach content analysis of American White Pelicans to assist in quantitative assessment of piscivorous consumption by this species. Gulls will be collected for stomach analysis at hotspots. Surveys for PIT tags and other fish prey remains will be conducted at various sites in the Yakima Basin and Columbia River such as heronries and pelican loafing or nesting sites.</p>
<b>4.b</b>	<p><b>Task:</b> Fish predation index: Monitor, evaluate, and index impact of piscivorous fish on annual smolt production of Yakima Subbasin salmon and steelhead.</p> <p><b>Hypothesis:</b> Ho: piscivorous fish will not significantly impact the survival of juvenile spring chinook and smolts, and ultimately limit supplementation success.</p> <p><b>Rationale:</b> Fish predators are capable of significantly depressing smolt production. By indexing the mortality rate of upper Yakima spring chinook attributable to piscivorous fish in the lower Yakima River, the contribution of in-basin predation to fluctuations in hatchery and wild smolt-to-adult survival rate can be deduced.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and Trends; Action Effectiveness: What is the effect of management alternatives / actions used to reduce the impact of piscivorous predators?</p> <p><b>Methods:</b> The abundance of northern pikeminnow (NPM, <i>Ptychocheilus oregonensis</i>) during the smolt outmigration will be estimated using mark/recapture methods in representative reaches of the middle Yakima. Predator-specific smolt consumption data will be gathered in the same reaches. All new NPM over 200+ cm will be tagged with a PIT tag and upon recapture all fish will be scanned for the presence of a PIT tag. If a PIT tag is found the tag code, fork length, and GPS coordinates will be recorded. In addition to GPS tracking of recaptured NPM, radio tags will also be attached to some fish to determine site fidelity of PIT tagged NPM. This information will be used to determine if PIT tagged fish are remaining in the sample areas</p>

	that will be used to estimate NPM populations. From this data, reach-specific Predation Indices will be calculated. Results from representative study reaches will be extrapolated from the Yakima Confluence to Roza Dam.
4.c	<p><b>Task:</b> Non-Target Taxa of Concern (NTTOC) monitoring: Determine the impact of spring chinook supplementation and coho salmon reintroduction on the abundance, distribution and size structure of 15 NTTOC in the Yakima basin.</p> <p><b>Hypothesis:</b> H<sub>0</sub>: Spring chinook supplementation will not depress the stock status (abundance, distribution, or size structure) of NTTOC below specified levels (See quantitative objectives).</p> <p><b>Rationale:</b> Hatchery supplementation may impact species (e.g. competition, predation, disease) that are not targeted for supplementation. This could result in an unfavorable suite of ecological benefits and costs.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and trends; Uncertainties research: Can properly designed intervention programs using artificial production make a net positive contribution to recovery of depressed populations?</p> <p><b>Method:</b> We will determine the affects of salmon supplementation on the abundance, distribution, and size structure of 15 NTTOC using three sequential steps as outlined by Pearsons and Temple (submitted): First, we will determine if spatial overlap occurs between supplementation fish and NTTOC. Second, if overlap occurs, we will determine if a change in abundance or size occurs during supplementation. Lastly, if a change exceeding NTTOC containment objectives occurs, we will determine if the change could be reasonably attributed to supplementation using a before-after-control-impact paired site analysis (Stewart-Oaten et al. 1986).</p> <p>We will use monitoring prescriptions that were developed to maximize our sensitivity to detect changes. Previous work identified the difficulty in detecting changes using abundance monitoring alone (Ham and Pearsons 2000). Subsequent work identified improvements in detecting changes by using alternative measures including spatial overlap, use of analogs, and modeling. Spatial overlap is used for species that are located upstream of target species acclimation sites during the baseline period (e.g., bull trout and tributary cutthroat trout). Increases in distribution of the target species can result in spatial overlap with NTTOC resulting in the potential for impacts. If overlap never occurs, then impacts are assumed to be negligible. However, if overlap does occur, then changes to status must be investigated. NTTOC that have similar ecological responses to interactions are used as analogs if they significantly improve the ability to detect changes. The use of analogs is particularly useful when NTTOC are rare and dispersed, and therefore difficult to sample. Finally, modeling of flow is used to reduce the amount of unexplained variation in an NTTOC response variable. We follow the risk containment approach for detecting and protecting NTTOC described by Ham and Pearsons (2001).</p> <p>We will use NTTOC stock status (abundance, size structure, and distribution) and interactions experiments to evaluate changes for 15 NTTOC. Intensive sampling will be directed towards bull trout, steelhead (age 1 mainstem rainbow trout as an analog), mainstem rainbow trout, and rainbow and cutthroat trout in tributaries. Stock status for all other NTTOC will be collected incidentally through existing sampling. Changes in NTTOC status or surrogate measures will be detected with a one-tailed t-test and results will be expressed as % changes from baseline. The statistical power of each test will be calculated to determine the probability of committing a type II statistical error (Ham and Pearsons 2000).</p> <p>Field sampling techniques including backpack and drift boat electrofishing, visual estimating, smolt counts at CJMF, and snorkeling will be used to monitor NTTOC abundance, size structure, and distribution (Table 5; Ham and Pearsons 2000, Pearsons et al. 2005).</p>
4.d	<p><b>Task:</b> Pathogen sampling: Determine the impacts of pathogens on supplementation success and supplementation impacts on the incidence of pathogens in wild Yakima spring chinook smolts.</p>

<p><b>Hypothesis:</b> H<sub>0</sub>: Spring chinook supplementation will not increase the incidence of pathogens in wild smolts.</p> <p><b>Rationale:</b> Artificial production could increase the incidence of pathogens in wild smolts thereby limiting success.</p> <p><b>Relationship to Regional Monitoring Framework:</b> Status and trends; Uncertainties research: Can properly designed intervention programs using artificial production make a net positive contribution to recovery of depressed populations?</p> <p><b>Method:</b> In order to determine if supplementation increases the incidence of pathogens, we will monitor levels of pathogens compared to a baseline data set describing existing levels of pathogens in wild spring chinook prior to introduction of hatchery fish. We will collect approximately 200 wild spring chinook smolts at CJMF throughout the migration period and later examine for fish pathogens using standard fish health screening protocols at the WDFW fish health laboratory to calculate a fish pathogen index. Pathologists generally recommend a sample of 60-90 fish to describe pathogens in wild populations. We sample 200 fish because we want to determine the temporal nature of pathogen presence in smolts throughout the migration period. In addition to the smolts samples, naturally produced adults collected for broodstock are inventoried for pathogens during spawning at the Cle Elum Hatchery. Furthermore, juvenile fish that are reared in the hatchery and acclimation sites are routinely screened for pathogens. This will allow us to compare pathogen loads in hatchery fish to pathogen loads in wild smolts.</p>
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The following is taken from:

Natural Production and Domestication Monitoring of the Yakima Spring Chinook Supplementation Program: December 2005 Revision. Chapter 7 in Busack, Craig, Anthony Fritts, Todd Kassler, Janet Loxterman, Todd Pearsons, Steven Schroder, Maureen Small, Sewall Young, Curtis Knudsen, Germaine Hart, Paul Huffman, "Yakima/Klickitat Fisheries Project Genetic Studies; Yakima/Klickitat Fisheries Project Monitoring and Evaluation", 2005-2006 Annual Report, Project No. 199506325, 205 electronic pages, ([BPA Report DOE/BP-00022370-5](#)). (See Appendix A).

This document further describes many of the research, monitoring, and evaluation objectives and strategies for this project. It generally applies to Sections 1.10, 11, and 12 of the HGMP.

## **Natural Production and Domestication Monitoring of the Yakima Spring Chinook Supplementation Program**

Yakima/Klickitat Fisheries Project Monitoring Implementation Planning Team

Revised December 14, 2005

### **Introduction**

The Yakima spring chinook supplementation program began in 1997 with broodstock collection at Roza Dam and spawning, incubation, and rearing at the Cle Elum Supplementation and Research Facility (CESRF). An intensive monitoring effort in natural production, genetics, and ecological interactions (Busack et al. 1997) was begun even before the hatchery operations started, and has continued. ISRP Review coincident with the first return of adult (4-year old) fish in 2001 raised concerns that the project was not sufficiently aggressive and rigorous in evaluating domestication. The result was an expanded domestication monitoring plan that began in the fall of 2002. The expanded domestication monitoring plan was first described in Busack et al.(2002), and revised in 2003 (Busack et al. 2003) and in 2004 (Busack et al. 2004).

The basic design of the domestication monitoring effort is to the best of our knowledge unmatched anywhere. The performance of the supplemented Upper Yakima spring chinook population, an *integrated* population sensu Hatchery Scientific Review Group (HSRG) (2004) with 100% natural-origin broodstock, is compared to the performance of an Upper Yakima control line maintained under a regime of continuous hatchery culture, and to an unsupplemented wild control line in the neighboring Naches River. Performance is measured at 14 adult and 15 juvenile traits that encompass virtually the entire range of domestication impacts noted in the literature. Details on the traits are presented in the Trait, Protocol and Analysis Overview section below.

The domestication monitoring plan last modified in 2004 was far reaching, actually covering many aspects of supplementation performance beyond domestication, but in this document we revise it even further in the direction of supplementation evaluation in response to a recent issue paper on supplementation monitoring by the ISRP/ISAB (2005) and a comprehensive overview of supplementation by Goodman (2004). This document stressed the need for supplementation projects to be evaluated in three areas: demographic benefits, long-term fitness, and ecological interactions. Ecological interaction monitoring is described elsewhere in this proposal, but two new major efforts are proposed for natural production and fitness monitoring, as recommended in the ISRP/ISAB report. The first is a pedigree study called *Target Population Natural Replacement Rate* (trait A2, below), in which the reproductive success in the wild of natural-origin and hatchery-origin fish can be compared. Additionally, by continuing this program over multiple generations, the possibility exists for detection of a clear signal for a genetic trend in reproductive success. The second critical change is an expansion of trait A1, now called *Productivity: Female Recruits Produced per Naturally Spawning Female*. The new revised program we propose here then consists of 14 adult and 15 juvenile traits.

## **Experimental Lines and General Hypotheses**

A. *Supplementation line (S)*: the Upper Yakima spring chinook population, supplemented annually by production from 16 raceways at CESRF and associated acclimation sites at Jack Creek, Easton, and Clark Flat. Broodstock collection is at the Roza Adult Monitoring Facility (RAMF) at Roza Dam. In contrast to most hatchery programs, broodstock are collected randomly throughout run, and consist of 100% natural origin fish. Other aspects of the program are as already described in numerous project documents.

B. *Wild control line (WC)*: Naches River spring chinook. The Naches River spring chinook occur in the Naches arm of the Yakima basin. Because they will not be supplemented during the study, they are available as a wild control line. We have determined that Naches fish can be used for 7 of 14 adult traits and 6 of 15 juvenile traits in our design, provided we can adequately sample fish on the spawning grounds, and collect gametes from a minimum of 10 pairs per year for research. These gametes are used for production of juveniles for research and for evaluation of some adult traits. Spawning ground surveys are already routinely done. To minimize impacts to the control population, collection of gametes from the Naches population is minimal, semen and partial egg lots from 10-30 pairs per year, depending on run size. We anticipate that in the future we may also be able to sample and collect fish at a trap at the Cowiche Dam on the lower Naches River. This trap is designed to collect coho salmon, so some modifications to the trap or the dam itself may have to be made to facilitate the efficient capture of chinook.

C. *Hatchery control line (HC)*: a subline of the Upper Yakima population founded from returning hatchery fish collected from throughout the 2002 adult run at the RAMF. Two of the 18 CESRF raceways (randomly chosen each year) will be dedicated to rearing of this line. These fish will be the offspring of a minimum of 36 pairs of fish, which should provide the HC line an effective size of at least 100 per generation. A larger line of HC fish was deemed to be



politically untenable because of the large number of fish that would potentially have to be removed at Roza Dam. Larger effective size would be preferable, but this is far larger than the minimum of 50 for quantitative genetic studies deemed to be adequate by Roff (1997). Because the number of fish used to found the HC line is relatively small, the decision was made to have a single line to avoid the possibility of smaller replicate lines going extinct. HC fish will be reared and released exactly as will their supplementation line (S) counterparts. No HC fish will be allowed to spawn in the wild; any returnees in excess of broodstock needs will be removed at the Roza adult monitoring facility (RAMF).

By comparing the supplemented line to both controls, we will address two key questions: 1) how much domestication is incurred by a population undergoing YKFP-style supplementation?; 2) how much less domestication is incurred under YKFP-style supplementation than would be incurred under continuous hatchery culture?. As already mentioned, because the wild control line is not an internal control we know at the outset that there will be differences in mean performance at several traits. As supplementation proceeds, if there is no discernible effect of domestication, the differences in mean trait values between the two lines should not change except for random fluctuations. If domestication does occur, however, the S line means will change and should continue to change over generations as domestication changes proceed directionally. The net effect will be a trend of increasing or decreasing differences between the supplemented and wild control line over generations. Comparisons between the hatchery control and supplemented lines will be somewhat different. Performance in the two lines should be equivalent initially because the hatchery control is an internal control. If domestication does not occur, performance of the two lines should remain the same except for random fluctuations and a small amount of drift due to the relatively low effective size of the hatchery control line. If domestication does occur, both lines will be affected, and the hatchery control line should be more affected. Thus performance at any trait should change in the same direction in both lines, but change should be greater in the hatchery control line. The rate at which the two lines diverge will be a reflection of the extent to which domestication can be retarded by the regular cycling of hatchery fish into the wild environment facilitated by the exclusive use of natural-origin broodstock. Details on expectations for individual traits are found below.

We also have cryopreserved the sperm of approximately 200 presupplementation Upper Yakima males and stored these gametes at the large cryopreservation facility at Washington State University. This will give us the potential to evaluate divergence of the supplementation line from its presupplementation state. This design concept has a number of issues associated with it, but it may be desirable to do this type of work at some level at some time in the future.

## **Experimental Power Concerns**

### *Hatchery Ancestry and Power*

The fact that the Yakima spring chinook program has complete control over broodstock composition and has a policy of 100% natural-origin broodstock makes this a well controlled, low variability system for monitoring cumulative effects of hatchery operations. We will deal first with the issue of control of hatchery effects. Simple modeling based on Ford (2002) and Lynch and O’Hely (2001) shows that the genetic dynamics of an integrated hatchery program is controlled by two gene flow rates: the proportion of natural-origin fish in the hatchery broodstock (pNOB), and the proportion of natural spawners comprised by hatchery-origin fish (pHOS). The proportion of time the population spends in the hatchery, called proportionate hatchery influence (PHI) is given by  $PHI = \frac{pHOS}{pHOS + pNOB}$ . Simulations of integrated

systems show that after the initial generation or two, the rate of increase of hatchery ancestry (generations of exposure to the hatchery environment) in the natural-origin fish in the population is equivalent to the program’s PHI. For a program like the Yakima spring chinook program, in which all broodstock are natural-origin fish (pNOB=1.00) and the proportion of hatchery-origin fish on the spawning grounds is approximately 50% (pHOS=0.5), PHI=.33. ISRP/ISAB stress the need for control of the proportion of hatchery fish on the spawning grounds, something that is typically unacceptable to project managers. It is important to point out in this regard that although the Yakima spring chinook has no control of hatchery fish on the spawning grounds except for a small selective sport fishery, because of the natural-origin only broodstock rule, the PHI of the population is likely to fluctuate only between 0.33 (pHOS=0.5), and 0.44 (pHOS=0.8). Any other program having a fixed pNOB will have a similarly limited PHI range, but fixed-PHI programs are rare. Thus even without explicit controls on pHOS, the Yakima spring chinook program is fairly well “controlled”.

Now we will consider the issue of variability of response. Our simulations of the buildup of hatchery ancestry in integrated programs have highlighted one other issue related to experimental power: variation in hatchery ancestry within a generation. Assuming the performance of fish in trials of domestication is related to the amount of hatchery ancestry, the variance in response of fish to experimental situations will depend on the variance of hatchery ancestry. Interestingly, our simulations show that in an integrated program the variance builds rapidly and then reaches a constant value that does not decline. There is no obvious pattern at this point, but different pNOB-pHOS combinations result in different characteristic variances. Important for this study is the fact that programs with 100% natural-origin broodstock will have considerably smaller variances than those with less than 100%. For example, a pHOS range of 0.5 to 0.8 will result in an ancestry variance range of 0.058-0.087 for a program with pNOB=1.0; for a program with pNOB=0.5, the range will be 0.16-0.25. For almost all types of monitoring, the project’s low variance in ancestry is an asset, but for multiple-generation pedigree analysis (see trait A2), where contemporaneous comparison of the reproductive success with a wide variety of hatchery ancestries is desired, the low variability may be problematic. We have yet to evaluate the potential impact on power in this case.

### *Precocious Males*

One issue regarding this design that has been the subject of considerable discussion is “leakage” from the H line into the S line through precocious males from the H line spawning in the wild with S-line females. If this occurs at an appreciable rate, it will bias the H-S and S-W comparisons, making the supplementation treatment appear more domesticating than it is, and also, the S line will undergo more domestication than it should for the lifespan of the H line, a conservation concern. Power analysis (Busack et al. 2004) indicates that under current levels of precocity, the bias should be negligible, but work is currently underway to evaluate this risk from a variety of angles, including measures for reducing production of precocious fish (Larsen et al. 2004). The precocious males will be a source of ungenotyped fish in the pedigree study (trait A2), which can bias comparisons of relative reproductive success (Araki and Blouin 2005).

### *Selective Fishery Impacts*

Hatchery-selective fisheries in the lower Columbia River are a relatively recent phenomenon and have the potential to bias a number of trait comparisons. This would occur when a fishery selectively removes hatchery fish (identified by their clipped adipose fin) possessing a particular phenotypic or life-history trait(s) (i.e. size-selective removal of larger fish would result in smaller size at age for those fish escaping the fishery, as well as, lower mean age at return). The magnitude of the bias is a function of both the fishery’s exploitation rate (greater rate, greater effect) and selection differential (larger selection differential, larger effect). We will use data from CWT tag recoveries of CESRF fish in the selective fisheries, e.g. lengths, ages and sex, and compare them to the SH and HC recoveries at RAMF to determine if selection is occurring and adjust our RAMF recovery data accordingly.

The impacted traits are only those involving comparisons between tagged SH or HC fish and untagged SN or WC fish. This includes size-at-age, age-at-return, sex ratio, and juvenile-to-adult survival or productivity rates. The comparisons of SH and HC fish are not affected since both groups are equally impacted by the fishery.

### **Trait, Protocol, and Analysis Overview**

The following pages provide details in a standard format, one trait at a time, on the 14 adult and 15 juvenile traits we intend to evaluate with this design. Most traits will be evaluated annually in order to maximize power, but some may be done less frequently due to logistical limitations. Protocols may vary from year to year to allow collection of key baseline information some years, and experimental data in others. For many traits it is important to distinguish between S line fish of hatchery-origin and those of natural origin: we call these two “sublines” SH and SN in the write-ups. This distinction is made to allow a cleaner measure of genetic differences. Consider nearly any comparison of HC and S fish. Part of the difference in performance between SN and HC fish will be genetic, but part may also be phenotypic, due to the effect of being reared in a hatchery. If HC fish are compared to SH fish, because they share the phenotypic effect of hatchery rearing, the performance difference will be exclusively genetic. It is important to keep

in mind when reading the write-ups, however, that although we call SN and SH lines in describing experimental designs, they differ only in their rearing history. Any given pair of SN and SH fish can have the same grandparents.

Although we will make most comparisons annually, annual comparisons within a supplementation generation (slightly more than 4 years) are merely replicates. Although significant domestication effects may be detected in a single generation, we expect the big results to be trends in performance over generations, so the write-ups stress the importance of trends. Our analyses are focused on measures of central tendency (means and medians). We have not focused on variability, primarily because we have virtually no expectations based on the literature on how variability should change under domestication at individual traits. We do have a working hypothesis that variability should decline during domestication because the considerably more homogeneous environment allows directional selection to be more effective. On the other hand, relaxation of selection caused by the hatchery environment could cause an increase in phenotypic variability. Variability at traits is therefore of interest to us. We doubt we will have enough power at any trait to detect a change in variability statistically, but we may see qualitative changes that will inspire further research.

The number of traits to be evaluated can be misleading. Many of the traits are measured on the same fish with no difference in protocol except for the measurement. Thus, the “effective” number of traits in terms of logistics and cost is considerably lower. The best example of this is the set of traits A7-A9, which are all measurements of reproductive traits on the same specimens. We list the measurements as separate traits because we consider them all important, and because we want to insure they are all done. Some traits require considerable effort and cost, whereas others will be measured in the course of ordinary fish culture operations. Our guiding philosophy was to take advantage of the opportunities offered by the CESRF and other facilities in the basin to measure as many traits relevant to domestication as feasible while minimizing impacts to the supplementation effort and the wild control population.

## **Nomenclature for Experimental Groups**

The key to making sense of the write-ups is understanding which groups of fish are being compared. In previous versions of the domestication monitoring plan the nomenclature system for the fish to be used in the various comparisons has caused considerable confusion. In this revision we introduce a new system that should clear the confusion. Here is the new system of codes:

**SN - naturally produced fish from the supplemented line.** This designation is used for both juveniles and adults. Any natural-origin fish in the Upper Yakima qualifies as an SN fish.

**SH – hatchery-origin fish from the supplemented line.** This designation is used for both juveniles and adults produced by the CESRF as part of its normal supplementation effort (i.e., not part of HC or any experimental production group).

**SH<sub>P</sub> – hatchery-origin progeny of SH adults.** This designation is used only for juveniles. With the exception of the spawnings needed to start the HC line, no SH adults are ordinarily spawned at the CESRF. For some comparisons, however, it will be necessary to spawn small numbers of SH adults at CESRF. The juveniles produced from these spawnings will not be reared past early stages and will not be released.

**HC- fish from the hatchery control line.** This designation is used for both juveniles and adults. All HC fish are of hatchery origin. The hatchery control line was founded from first-generation hatchery returnees, so in that generation there is no distinction between SH adults and HC adults, but thereafter the distinction is clear.

**WC-natural-origin fish from the wild control line.** This designation is used for both juveniles and adults. Any natural-origin fish in the Naches qualifies as an WC fish.

**WC<sub>P</sub> – hatchery-origin progeny of WC adults.** This designation is used for juvenile fish. Small numbers of WC adults will be captured and spawned. Some of the resulting hatchery-origin progeny will be used in comparisons.

Table A.5. Tasks required for use in the adult and juvenile domestication traits.

Trait	Tasks required	Trait	Tasks required
A1	1c, 1h, 1i, 1j, 2b	J1	1c, 1i
A2	1c, 1i	J2	1c, 1i
A3	1c, 1i, 1j, 1m, 2a, 2b	J3	1c, 1i
A4	1c, 1i, 1j, 1m, 2a, 2b	J4	1c, 1i
A5	1c, 1i, 1j, 1m, 2a, 2b	J5	1c, 1i
A6	1c, 1i	J6	1c, 1i
A7	1c, 1i, 1j	J7	1c, 1d, 1e, 1i
A8	1c, 1i	J8	1c, 1e, 1i
A9	1c, 1i, 1j	J9	1c, 1i, 1m
A10	1c, 1i	J10	1c, 1d, 1e, 1i
A11	1c, 1i	J11	1c, 1i
A12	1c, 1i, 1j	J12	1c, 1i
A13	1c, 1i	J13	1c, 1i
A14	1c, 1i	J14	1c, 1i
		J15	1c, 1i

Start dates for the adult and juvenile traits are as follows:

2001 – A10, A11, J3, J4.

2002 – A1, A3-A9, J5, J6, J9, J11, J12.

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2003 – A12, J13 (HC, SH), J14 (HC, SH).  
2004 – J1, J2.  
2005 – J13 (HC, SH, WC), J14 (HC, SH, WC).  
2006 – A2 (proposed), A13, A14, J7, J8, J10, J15.

Frequency of data collection for all traits are on an annual basis with the following exceptions:

A2 – Data collection over two or more generations with the possibility of some flexibility as to how many years within a generation need to be sampled. Analysis can occur later as funds become available.

A13 – Annually for four years.

A14 – Annually for four years.

## **A1. Productivity: Female recruits produced per naturally spawning female** (revised 12/21/05)

### ***Background and Justification***

The success of any supplementation effort should be based on tracking population productivity through time. One of the best measures of population-wide productivity is the number of female offspring produced per female spawner. If supplementation is succeeding, this metric will either increase or remain stable until density factors on the spawning grounds or rearing areas impose biological limits on the population. On the other hand, if the ability of hatchery-origin females to produce offspring under natural conditions has been reduced because of inadvertent domestication, then the overall productivity of a population will decrease even when density-limiting factors are not in action. To obtain estimates of productivity for Yakima River spring Chinook the number of female offspring produced from females spawning naturally in the river will be determined on a brood year basis. Productivity can vary from one brood year to the next because of environmental differences. That is why we will also track the productivity of spring Chinook females spawning in the Naches. None of these fish will have experienced any hatchery exposure and they will be spawning and rearing in areas similar to those experienced by the upper Yakima population. Thus shifts in their brood year productivity values will be a good representation of how various environmental effects influenced overall productivity.

***Location*** RAMF, Prosser Dam, Upper Yakima, Naches, American spawning ground

***Groups Compared*** WC, SN, and SH

### ***Protocol***

At Prosser adults from all populations in the basin are counted and classified as hatchery or natural, resulting in counts for hatchery origin (HC+SH) and natural origin (SN + American + Naches (WC)) fish. At RAMF, SH, SN, and HC fish are counted, sampled for sex, age and POH length. Sex data for the HC and SN groups will come from fish captured and taken to CESRF for brood stock. Sex determinations for the SH group will be obtained from DNA samples collected at RAMF. DNA sexing is necessary because error rates of approximately 30% in males and 10% in females occur at RAMF each year based on morphological sexing of live fish (Knudsen et al. 2002, 2003). An estimate of the abundance of spring Chinook returning to the Naches and American rivers will be made by comparing Prosser and Roza counts after adjustment for harvest and incidental in-river mortality. Redd counts will be obtained from spawning ground surveys on the Naches and the American rivers. Final Naches adult counts will be calculated as the product of the Naches and American escapement and the Naches proportion of the Naches and American redd counts. Additional adjustments may be made to correct for sex ratio bias on the spawning grounds. Adult females produced per adult female spawner by brood year can be estimated for WC, HC, SH, and S natural spawners (mix of SN and SH spawning in wild). It will also be necessary to include in the analysis at least two additional factors: female spawner density and the proportion of hatchery fish spawning each year. Spawner density adjustments will require calculating a density-dependent function for each population. The proportion of hatchery fish naturally spawning each year may have a significant impact on natural productivity and should be included in the analyses.

In addition to the general productivity measures described above, critically important insights into the relative productivity of hatchery- and natural-origin females could be gained if micro-satellite DNA samples were collected on each adult processed through RAMF. In this case, each female returning to spawn could be classified as coming from an SHxSH, SNxSH, SHxSN, or SNxSN mating. The proportions of the females originating from these matings could be compared with the proportions expected to return based on the number of SH and SN adults present on the spawning grounds during their brood year.

### ***Expectations/Hypotheses***

If domestication does not occur, differences in productivity of naturally spawning females among groups will remain constant over time after adjusting for inter-annual density effects. Conversely, if domestication does occur we would expect the productivity of SH females naturally spawning to

decrease over time reducing the productivity of the aggregate mixture of naturally spawning females. The reduction will be a function of the effects of domestication and the proportion of SH females on the spawning grounds. Thus, the proportion of females of SH origin naturally spawning each year must be estimated. HC fish will be intercepted at RAMF and not allowed to naturally spawn.
<b>Analytical/Statistical Methods and Issues</b>
Within brood years no statistical analysis will be done. However, over brood years, analysis of covariance will be used to evaluate differences in trends. Trend analysis will take into account year-to-year spawner density effects and the proportion of SH females on the spawning grounds.
<b>Findings To Date</b>
No analyses have been completed to date. This productivity metric has just been added to the Domestication plan.

<b>A2. Target Population Natural Spawning Replacement Rate</b> <i>(revised 12/21/05)</i>
<b>Background and Justification</b>
Part A. Relative Reproductive Success of Hatchery-origin and Natural-origin fish. According to the ISRP and ISAB (2005), to determine whether natural production lost due to removing spawners for hatchery production is replaced by naturally reproducing hatchery-origin fish requires evaluation of target population natural replacement rate. They further state that to do this the progeny of four types of matings on the spawning grounds must be enumerated: HxH, NxN, NxH, HxN. In addition to explicitly providing this information, this effort will also provide information that can be used in reducing bias in trait A1 (see trait A1 write-up).  Part B. Genetic Decline in Fitness If carried out for multiple generations, because of differing levels of hatchery ancestry, genetic impact of domestication on reproductive success can be measured by comparing the relative reproductive success of fish with differing levels of hatchery ancestry.
<b>Location(s)</b> RAMF
<b>Groups Compared</b> SN fish from HxH, NxH, HxN, and NxN matings
<b>Protocol</b>
The basic idea is to sample all returning S fish (both SH and SN) at RAMF for DNA, then sample all their progeny at RAMF a generation later. Progeny will be then be assigned to parents by CEVUS (Marshall et al. 1998) or a similar program. For a year of parents sampled, progeny will have to be sampled over multiple years to get complete returns (fish return at 3,4, and 5 years of age). All fish will be aged to assign to correct brood year. Sampling will continue through multiple generations for Part B.
<b>Expectations/Hypotheses</b>
Based on a recent study of reproductive success of a recently created native steelhead stock in the Hood River, OR (Blouin 2003), we expect the relative reproductive success of hatchery-origin fish to be perhaps 15% lower than that of natural-origin fish. How much of this will be due to genetic causes is unclear. If this is only phenotypic, we would expect this fitness difference between natural-origin and hatchery-origin fish to remain over multiple generations. Over time we would expect the base fitness level in the population to decrease as hatchery ancestry increases, but at what rate it unclear. Several cases have been noted of long-established hatchery stocks having much lower fitness in the wild than natural-origin fish (Chilcote et al. 1986; Blouin 2003), but these were with long established nonnative stocks, and they were steelhead, not chinook.
<b>Analytical/Statistical Methods and Issues</b>
At least ten loci, the same loci used in the spawning channel pedigree study (Kassler 2005), will be used, but potentially more will be needed because of the complexity involved in creating a pedigree for such a large population. Ugenotyped fish is a twofold issue. There will be ungenotyped parents because we will not be able to sample precocious males, but we will also want to limit genotyping of returning adult fish as a means of reducing cost (there may be as



many as 10,000 returnees in some years). At this point it appears that power analysis will be done by using CERVUS (Marshall et al. 1998), but other available programs may be used as well. Assessment of bias (Araki and Blouin 2005) will be a key part of the power analysis. Power analysis of part B will be multiple stage, as fish will essentially need to be assigned to grandparents. For analysis of part A, simple assignment by CERVUS with bias adjustment will yield per fish estimates of relative reproductive success, which will be then be grouped in results by mating type. For analysis of part B, estimates of relative reproductive success will be regressed on hatchery ancestry inferred from the pedigree to yield estimates of genetic fitness loss per generation.

**Findings to Date**

None specifically on this trait, however we have been doing pedigree analysis on fish in the spawning channel for three years (Kassler 2005), so procedures are well established except for above-noted power concerns.

**A3. Age composition by sex** (revised 12/21/05)

**Background and Justification**

Age composition or age at maturity is a trait related to fitness. For example, older females generally have higher fecundities, larger eggs and larger body sizes all of which may affect their overall fitness. Older males are also generally larger than younger ones and size in males may play a significant role in the ability of fish to successfully court and spawn with females. Age determinations are also required in order to reconstruct demographics based on brood years. While significant differences exist between natural populations of spring chinook in the Yakima River (Knudsen et al. 2006), within-population age composition is relatively stable. However, in some hatchery populations, fish may mature at younger ages, perhaps reflecting the impact of more rapid growth or a genetic change (Gallinat et al. 2001). Hence, the age of maturity of hatchery- and natural-origin fish will be tracked to see if sex-specific changes in maturity occur because of exposure to hatchery conditions.

**Location** RAMF, CESRF, Naches spawning grounds

**Groups Compared** WC, HC, SN, and SH

**Protocol**

Requires sex and age determination of adequate samples of fish. For all fish used in the hatchery (SN and HC for production, few SH for research) and for those sampled on the spawning grounds as carcasses (WC), sex can be determined visually. Sex determination based on visual inspection of green fish is not reliable, e.g. 30% of the fish classified at Roza as males are females (Knudsen et al. 2003). SH fish are sampled in low numbers as carcasses, so sex determination for SH fish will be based on DNA analysis. Age will be determined on all fish by scale analysis or tags. Minimum target sample size is 140 for WC and 200 for SH (carcasses + DNA samples). This will provide estimates of age composition with multinomial confidence intervals of  $\pm 10\%$  or less at  $\alpha=0.05$  (Thompson 1987). Hatchery-selective fisheries in the lower Columbia River have the potential to bias our results by selectively removing hatchery fish with a particular phenotypic trait (i.e. size-selective removal would result in reduced age at maturity for those fish escaping the fishery). The magnitude of the bias is a function of the fisheries exploitation rate and selection differential. We will adjust our RAMF data using the method described in the *selective fishery impacts* section above.

**Expectations/Hypotheses**

Hatchery fish tend to return at younger ages than naturally produced fish (Gallinat et al. 2001), so younger age structures would be expected for HC and SH relative to naturally produced fish, and these differences may be only phenotypic. If domestication does not occur, differences in age structure among all four groups will remain constant over time. If domestication does occur we would expect age structure to decrease (Reisenbichler and Rubin 1999). Because HC should be most domesticated, its age structure should decrease more, but age structure of SH should decrease as well.

**Analytical/Statistical Methods and Issues**

Within years multinomial contingency tests will be used to compare age structures. Comparison

of HC and SH will be especially informative for determining genetic effects. Over years analysis of covariance will be used to evaluate differences in trends. Analysis will be complicated by the fact that age structure is in part a reflection of the genetic composition of the population, but can be strongly influenced by environmental fluctuations in brood-year survival and by hatchery selective fisheries.

**Findings To Date**

F1: Most SH and SN fish of both sexes reached maturity at age 4 (>76%), followed in magnitude by ages 3 and 5. However, SH mean age at maturation declined significantly due primarily to an increase in age 3 males over time, while SN mean age at maturation demonstrated no significant trend over time (Knudsen et al. 2006).

F2: These general trends have continued into the second generation (return year 2005) and are likely in 2006, although those data have not been analyzed on a brood year basis, yet. Analyses of 2005 and 2006 will be integrated with 2007 and 2008 to assess the impacts in F2 (Knudsen et al. 2007).

**A4. Size-at-age by sex** (revised 12/21/05)

**Background and Justification**

Gallinat et al. (2001) observed that hatchery-origin adults were significantly smaller than wild cohorts that matured at the same age. How universal this phenomenon may be is unknown, but similar reductions in size have been observed in other salmon populations including those produced from the CESRF. Size at maturity is plainly influenced by environmental as well as genetic factors. Currently, the relative importance of these factors on size at maturation is unknown. The HC and SH lines at the CESRF provide a unique opportunity to evaluate how additional generational exposure to a hatchery environment may affect body size. These comparisons will put into context by also evaluating trends in body size of adults returning to the Naches spawning grounds.

**Location** RAMF, CESRF, and Naches spawning grounds

**Groups Compared** WC, HC, SN, and SH

**Protocol**

Protocol same as for trait A3 (same fish) but with post-orbital hypural (POH) lengths measured

**Expectations/Hypotheses**

For unknown reasons, hatchery fish have been observed on several occasions to be smaller than naturally produced fish of the same age; e.g., 2001 returnees to Cle Elum were ~2 cm shorter than naturally produced fish (Knudsen et al. 2003 and 2004; also see (Gallinat et al. 2001); Fresh et al. 2003), so smaller sizes would not be surprising in HC and SH relative to naturally produced fish, but these differences may be only phenotypic. If a reduction in size at age is primarily driven by some aspect of the hatchery environment, then we would expect an initial reduction in size of SH fish in the first generation followed by a constant difference in size between SN and SH returns over subsequent generations. In addition, there would be no difference in size between SH and HC fish over generations because they experience similar rearing environments. Assuming the smaller size observed in hatchery fish is in part a result of domestication (genetic), size can be expected to decline as domestication proceeds. Thus the size of the WC fish should remain constant, and the size of SH and HC should decline, with HC fish declining most. Hatchery-selective fisheries in the lower Columbia River have the potential to bias our results by selectively removing hatchery fish with particular phenotypic traits (i.e. size-selective removal would result in smaller size at age for those fish escaping the fishery). The magnitude of the bias is a function of the fisheries exploitation rate and selection differential. We will adjust our RAMF data using the method described in the *selective fishery impacts* section above.

**Analytical/Statistical Methods and Issues**

Within years, analysis of variance will be used to compare mean POH lengths. Comparison of HC and SH will be especially informative for determining genetic effects. Over years analysis of covariance will be used to evaluate differences in trends. If a reduction in size at age is primarily environmentally driven by some aspect of the hatchery, then we would expect an initial reduction in size of SH fish in the first generation followed by a constant difference in size between SN and

SH returns over subsequent generations. In addition, there would be no difference between SH and HC fish over generations.

**Findings To Date**

F1: For broodyears 1997 to 2000 mean lengths of 3–5-year-old SH fish were shorter than those of SN fish of the same age (differences of 2.7 cm for age 3, 1.7 cm for age 4, and 1.9 cm for age 5). Likewise, body weights of SH fish were lower than those of SN fish (differences of 0.3 kg for age 3, 0.3 kg for age 4, and 0.6 kg for age 5), representing a change in body size of between 0.5 and 1.0 standard deviation (SD) (Knudsen et al. 2006).

F2: These general trends have continued into return years 2005 and 2006, although the data have not been analyzed on a brood year basis, yet. Age 4 mean SH and HC body length and weight distributions at RAMF were significantly smaller than SN adults by 1.0 to 1.3 cm and 0.2 to 0.3 kg, but did not differ significantly between each other. In contrast, HC, SH, and SN age 3's were not significantly different and HC adults were largest (Knudsen et al. 2007a).

For the first time in 9 years we observed sexual dimorphism in body size of age 4 upper Yakima 2006 returns. Mean female POHP lengths were significantly greater than males (SN (male = 58.0, female = 59.6), HC (male = 56.8; female = 57.9), SH (male = 56.9; female = 58.0)). Body weight dimorphism followed the same general trend, but was not statistically significant between the sexes (SN (male = 3.6; female = 3.7), HC (male = 3.4; female = 3.4), SH (male = 3.4; female = 3.5)).

**A5. Sex ratio at age** (revised 12/21/05)

**Background and Justification**

Larsen et al. (2004) observed an increase in the rate of precocious development in males at the CESRF. Early maturation in males may have been caused by rapid growth interacting with a genetic proclivity to mature early. This should mean fewer males in the hatchery population will mature at later ages causing a shift in the sex ratio of SH and HC fish. How exposure to hatchery conditions may affect age of maturation in females is unknown. If there is a tendency for hatchery-origin females to mature at early ages then the value of these fish in supplementation efforts will be reduced because of their lower fecundities and decreased ability to provide protected incubation environments (van den Berghe and Gross 1984). The incorporation of a hatchery control line once again provides us with an opportunity to evaluate how multiple generational exposure to a hatchery environment may affect another adult trait that is linked to fitness.

**Location** RAMF, CESRF, and Naches spawning grounds

**Groups Compared** WC, HC, SN, and SH

**Protocol**

Protocol same as for trait A3 (same fish)

**Expectations/Hypotheses**

If domestication does not occur we would expect to see no changes in the sex ratios of fish maturing at different ages. If domestication does occur we anticipate that the HC line will produce fewer precocious males. Consequently, greater proportions of males will mature in older age classes (e.g. 3-, 4- and 5-yr olds) in the HC line. This hypothesis is based on the fact that precocious males are not used as brood stock. Hatchery-selective fisheries in the lower Columbia River have the potential to bias our results by selectively removing hatchery fish with particular phenotypic traits (i.e. higher catch limits for age-3 jacks would result in skewed sex ratios for those SH and HC fish escaping the fishery). The magnitude of the bias is a function of the fisheries exploitation rate and selection differential. We will use sex data from CWT tag recoveries of CESRF fish in the selective fisheries and compare them to the sex ratios of recoveries at RAMF to determine if sex-selection is occurring and adjust our RAMF SH and HC recovery data accordingly.

**Analytical/Statistical Methods and Issues**

Within years, binomial test of proportions will be used. Over years analysis of covariance will be used to evaluate differences in trends.

**Findings To Date**

F1: The proportion of SH males, primarily age 3, significantly increased from 38% to 49% over time for BY 1997-2000. Conversely, the sex composition of wild fish did not exhibit a similar increasing trend. The sex composition in BY1997-2000 SN and SH fish differed in three of four brood years. Although SH males began low relative to SN fish, but ended highest (Knudsen et al. 2006).

F2: These general trends have continued into return years 2005 and 2006, although the data have not yet been analyzed on a brood year basis. Analyses of 2005 and 2006 will be integrated with 2007 and 2008 to assess the impacts in F2 (Knudsen et al. 2007a).

**A6. Migration timing to trap (revised 12/21/05)****Background and Justification**

Time of spawning in Chinook salmon is a fitness related trait that is significantly influenced by water temperatures during the spawning and egg incubation periods (Brannon et al. 2004). Every spring Chinook that spawns in the Upper Yakima has to first pass through the RAMF and because those fish are inspected it is possible to document when HC, SH, and SN fish have migrated to Roza. We have found that passage date at the RAMF is either uncorrelated with spawn timing or explains no more than 4% of the variation in spawn timing (Knudsen et al. 2006). However, a population that passes RAMF later, assuming all populations spawn during the same temporal window, has fewer days on the spawning grounds to find and compete for mates and construct redds possibly having some negative fitness consequence. Therefore we plan to examine the effects of treatment origin (i.e. SH, SN, and HC) on when fish migrate to the RAMF.

**Location** RAMF

**Groups Compared** HC, SN, and SH

**Protocol**

Fish moving through the Roza Adult Monitoring Facility (RAMF) will be inspected for tags and marks making it possible to record the origin and date of passage of each fish.

**Expectations/Hypotheses**

No expectations on how this trait will change, but data will already be available to see if continued exposure to hatchery conditions (HC) causes a noticeable difference in when fish arrive at Roza and their ultimate spawning destination.

**Analytical/Statistical Methods and Issues**

Within years, a non-parametric test, either a Kolmogorov-Smirnov or Kruskal-Wallis ANOVA will be used on cumulative passage distributions. Over years, analysis of covariance will be used to compare trends in median arrival date. Run timing at RAMF is related to age, with older fish passing earlier (Knudsen et al. 2004). Therefore, if hatchery selective fisheries remove larger, older individuals that would have passed RAMF earlier, then migration timing could be biased to a later date. Again, comparison of size/age of CWT'ed fish recovered in the fishery and to those passing RAMF will help us understand if this is occurring.

**Findings To Date**

F1: Median arrival timing of adult (>age 4) SH and SN fish at RAMF showed no consistent difference between RY 2001 and 2004 (Knudse et al. 2006).

F2: Adult SH and SN median passage date at RAMF differed significantly (SN earlier) by 7 and 6 days for RY 2005 and 2006, respectively. SH jack median passage was 2 and 12 days later than SN jacks in RY 2005 and 2006, respectively. These were all significantly later each year in Kruskal-Wallis tests (Knudsen et al 2007a).

**A7. Spawning timing (revised 12/21/05)****Background and Justification**

When spring Chinook reach maturation and spawn is strongly affected by the water temperatures they encounter and the water temperatures their offspring are likely to experience (Brannon et al. 2004). Clearly, time of spawning is a fitness related trait as the offspring of fish that spawn too

early or late can suffer significant incubation and post-emergence mortality (Brannon 1987; Hendry et al. 1998; Smoker et al. 1998; Einum and Fleming 2000). We have found that natural spring Chinook populations in the Yakima River Basin exhibit differences in spawn timing that have evolved to maximize fitness (Knudsen et al. in prep.). Given this situation, an obvious question to ask is whether exposure to hatchery conditions will alter traditional maturation timing in Yakima spring Chinook. As in many of the other adult traits examined, the presence of HC, SH, SN fish as well as natural controls, will allow this question to be addressed.
<b>Location</b> CESRF, Upper Yakima and Naches spawning grounds
<b>Groups Compared</b> WC, HC, SN, and SH
<b>Protocol</b>
Monitoring this trait has two components: 1) comparing S -and WC temporal trends in redd count and carcass recovery distributions from weekly spawning ground surveys; and 2) comparing SH with HC spawn timing distributions in the hatchery.
<b>Expectations/Hypotheses</b>
Our expectation is that time of maturation will not change. Changes in spawn timing have been commonplace in hatchery operations, but this is likely tightly linked to taking eggs from the first part of the run. In this project we have made a concerted effort to take eggs in a representative fashion throughout the spawning season. Thus we do not expect to see a change in the time of spawning.
<b>Analytical/Statistical Methods and Issues</b>
Within years we will compare the temporal distributions of HC with SH spawners by using either the non-parametric Kolmogorov-Smirnov test or Kruskal-Wallis ANOVA. We will investigate whether the sexes differ significantly and require separate analyses. Within-year analyses of WC and SN fish will not be done, but median spawning/recovery dates for each of these groups will be calculated. Over years, analyses of covariance will be used on median spawning dates. One analysis will examine temporal changes in the HC and SH fish while another analysis will examine similar trends in WC, SN and SH fish. Naches information will likely not be very precise.
<b>Findings To Date</b>
F1: Maturation timing of SH fish averaged 5.2 days earlier than SN fish at CESRF (RY2001-2004) (Knudsen et al. 2006). F2: This trend has continued into return years 2005 and 2006 (Knudsen et al. 2007a). F1: Initiation of in-river female spawning activity did not differ between SH and SN fish (RY2002-2005) (Knudsen et al. 2005a)

<b>A8. Fecundity</b> (revised 12/21/05)
<b>Background and Justification</b>
Significant changes in locally adapted traits due to hatchery influences, whether of genetic or environmental origin, will likely be maladaptive, resulting in reduced population productivity and fitness (Taylor 1991; Hard 1995). Fecundity or the total number of eggs produced by a female, significantly affects maternal reproductive success and fitness in salmonids (Healey and Heard 1984; Fleming and Gross 1990; Beacham and Murray 1993). Fecundity, egg mass and egg size also reflect local adaptations to the conditions present on spawning grounds (Taylor 1991; Hendry et al. 1998; Quinn et al. 2001). Investigations that have examined how domestication may influence fecundity in hatchery populations have shown that egg number can be reduced (Fleming and Gross 1992; Petersson et al. 1996). Whether environmental or genetic effects cause such reductions is not currently known. Comparing the fecundities of HC, SH, and SN females, however, will provide information about the existence of genetic change due to repeated exposure to hatchery conditions.
<b>Location</b> CESRF
<b>Groups Compared</b> HC, SN, and SH
<b>Protocol</b>
Enumerate eggs from at least 30 females of each type (i.e SH, HC, and SN). This means that some SH origin females (a minimum of 30) will have to be held to maturity at CESRF.

<p>Conversely, fecundity samples from SN and HC females will be taken from fish being held for broodstock in the two lines. WC fish are not included because we intend to collect only partially spawned females and thus will not be able to get total egg counts. Fecundity will be estimated using a gravimetric methodology and corrected for bias based on a correction factor derived from a comparison of estimated fecundity (gravimetric) to known fecundity (hand counts) for a sample of females. Each year, corrected fecundity estimates of 10 females will be compared to their hand counts to determine whether our gravimetric estimation methodology is changing over time.</p>
<p><b>Expectations/Hypotheses</b></p> <p>If domestication does not occur, fecundity will remain constant. However, Fleming and Gross (1989; 1992) predicted that under hatchery culture fecundity will decrease, at least for coho salmon. Thus, we would expect fecundity to decrease in the SH and HC lines, and the decrease should be greater in HC.</p>
<p><b>Analytical/Statistical Methods and Issues</b></p> <p>Within years, analysis of covariance will be used to compare body traits vs. fecundity within age classes. Analysis of variance will be used within years to compare absolute fecundities within age classes. Over years analysis of covariance will be used on mean fecundity by age to detect trend differences among groups.</p>
<p><b>Findings To Date</b></p> <p>F1: After adjusting for broodyear and length differences, SN females averaged 234 more eggs than SH females for broodyears 1997 through 2001 (Knudsen et al. submitted).  F2: After adjusting for POHP, mean fecundity of HC (3,319.7 eggs; n=38) and SN (3,328.8 eggs; n=208) origin age 4 females were not significantly different (p=0.923). Mean fecundity in BY2002 was the lowest we have observed, reflecting the fact that age 4 body size was also the smallest recorded since beginning the collection of fecundity data (Knudsen et al. 2007b).</p>

<p><b>A9. Egg weight</b> (revised 12/21/05)</p>
<p><b>Background and Justification</b></p> <p>Heath et al. (2003) concluded that egg weight in Chinook salmon decreased by 27% after five generations of captive rearing. Furthermore, Heath et al (2003) speculate that exposure to hatchery conditions will decrease egg size in hatchery-origin females (see also Fleming et al. 2000). Alternatively, Fleming and Gross (1989; 1992) and Petersson et al. (1996) reported that egg size in hatchery salmonids increased. Egg weight is a very important biological trait as it has a significant effect on emergent fry size, yolk reserves at emergence (Thorpe et al. 1984; Hendry et al. 2001), incubation rates, and emergence timing (Beacham and Murray 1993; Quinn et al. 1995). Obviously, all of these egg-size related traits can clearly affect the survival and ultimate reproductive success of salmonids. Consequently localized natural selection pressures undoubtedly strongly influence this trait (Taylor 1991; Hendry et al. 1998; Quinn et al. 2001). As mentioned above, hatchery environments appear to affect egg size in a non-consistent manner. The goal of monitoring this trait is to determine whether egg size change is occurring because of exposure to hatchery conditions, and if so, to ascertain the rate and direction of that change.</p>
<p><b>Location</b> CESRF, Naches spawning grounds</p>
<p><b>Groups Compared</b> WC, HC, SN, and SH</p>
<p><b>Protocol</b></p> <p>Measure weight of individual eggs originating from WC, HC, SH, and SN females. Same fish used for trait A7. Requires holding some SH origin females (a minimum of 30) to maturity at hatchery in addition to the SN females that will be held for SN broodstock and the HC females that will be used for HC broodstock. Also requires sampling eggs from a maximum of 10 Naches females on spawning grounds. The coefficient of variation associated with egg weights from individual females is typically less than 2%. Consequently, five individual egg weights will be obtained from each sampled female.</p>
<p><b>Expectations/Hypotheses</b></p> <p>If domestication does not occur egg weight will not change. However, Heath et al. (2003) observed that egg weights declined in captive chinook populations while Fleming and Gross</p>

(1989, 1992) and Petersson et al. (1996) observed that under hatchery culture egg size increased. We would expect egg weight to change in SH and HC, and the change should be greater in HC. The direction of change is not known because of differing reports in the literature.
<b>Analytical/Statistical Methods and Issues</b>
Within years, analysis of covariance will be used to compare body traits vs. egg weight within age classes. Analysis of variance will be used within years to compare egg weights within age classes. Over years analysis of covariance will be used on mean egg weight by age to detect trend differences between groups. Naches females, because there will be so few of them, should represent a variety of sizes.
<b>Findings To Date</b>
No consistent difference in mean egg weights of SH and SN origin females has been observed (Knudsen et al. 2002, 2003c, 2004c, 2005d, in prep.). In both SN and SH females, eggs of age-5 fish are significantly larger than age-4's (ANOVA; $p < 0.01$ ). Trends in age-specific egg weights over time were not significant for either group ( $p > 0.35$ ). Eggs of WC females are significantly heavier than eggs of SH and SN females of the same size ( $p < 0.05$ ; Knudsen et al. 2005d). In 2006, 4-yr-old females from the HC line will be available for the first time making it possible to evaluate how two generations of exposure to hatchery conditions may affect egg size.

<b>A10. Reproductive effort</b> (revised 12/21/05)
<b>Background and Justification</b>
The biomass of gametes produced per unit body size indicates how populations have optimized allocation of energy between somatic growth, gametes, migration, competition and mating (Heath et al. 1999; Kinnison et al. 1998; Kinnison et al. 2001). In a hatchery setting, significant relaxation of selection pressures on reproductive effort (gonad weight divided by total body weight) may occur. Hatchery females, for example, do not have to allocate energy toward nest construction, spawning, guarding, and post-spawn redd sculpting. Similarly hatchery males do not have to invest energy into searching for and defending females and conducting courtship activities. In theory this energy could be reallocated and placed into gonads making the reproductive effort of hatchery fish higher than that seen in wild cohorts. An increase in reproductive effort (RE) has been observed in hatchery origin fish. If it occurs in our situation it could reduce the capacity of hatchery fish to reproduce under natural conditions because the energy they need to carry out reproductive behaviors would be irretrievably allocated to gametes. The goal of this trait evaluation is to determine if reproductive effort is increasing in our hatchery origin fish or whether this trait remains stable even when selection pressures affecting its expression have been notably relaxed.
<b>Location</b> CESRF
<b>Groups Compared</b> HC, SN, and SH
<b>Protocol</b>
Reproductive effort is calculated by dividing gonad weight by body weight. To collect this information, testes and total egg mass weights (sans ovarian fluid) will be measured in HC, SH, and SN fish. Testes weights will be collected from un-spawned HC, SH, and SN males. The acquisition of RE data in SH fish requires that some (a minimum of 30 pairs) be held at CESRF to maturity. Additionally, data from SN and HC fish will be taken from individuals that are being used as broodstock. WC fish will not be included in this analysis because partially spawned WC fish are being used as donors for our WC line and therefore it is not possible to measure the total weight of their unspawned gametes.
<b>Expectations/Hypotheses</b>
If domestication does not occur reproductive effort will remain constant. However, Fleming and Gross (1989,1992) and Jonsson et al. (1996) observed that under hatchery culture reproductive effort does increase. Thus, we would expect reproductive effort to increase in SH and HC, and the increase should be greater in HC over time.
<b>Analytical/Statistical Methods and Issues</b>
Within years, analysis of covariance will be used to compare body traits vs. reproductive effort

within age classes. Over years analysis of covariance will be used on mean reproductive effort by age to detect trend differences between groups. We cannot collect data on total gamete mass in Naches (WC) females (they are all partially spawned prior to collection), so we will not be able to estimate their reproductive effort.

**Findings To Date**

From 2001 through 2005 there were no differences between SH and SN origin age-4 females (2-way ANOVA; Origin effects  $p=0.64$ ; Knudsen et al. 2002, 2003c, 2004c, 2005d, in prep.). Male RE exhibited no significant difference between SH and SN fish in 2003 ( $p=0.54$ ; Knudsen et al. 2004c). The trend over time (2001 to 2005) in age-4 female RE was positive and significant ( $p=0.01$ ; Knudsen et al. in prep.), but explained less than 1% of the total variation in RE over time.

**A11. Male and female fertility (revised 12/21/05)**

**Background and Justification**

How fertility is affected by exposure to hatchery conditions is unknown and plausible arguments can be raised that it may be reduced or increased in hatchery fish. Because this trait is so closely linked to fitness it is important to understand if viability is influenced by hatchery exposure

**Location** CESRF

**Groups Compared** HC, SN, and SH

**Protocol**

The fertility of HC, SH, and SN fish will be estimated by creating *inter se* (within group) factorial crosses using 2x2 or 3x3 mating designs. Gametes from the fish used for trait A9 will be used. Some (a minimum of 30 pairs) SH origin males and females will have to be held to maturity at the hatchery in order to make the SH crosses. In addition gametes from fish being held for SH and HC fish broodstock that will be used to make the crosses necessary for these populations. When 2x2 crosses are performed a total of 4 families (2 for each male and female used) are created while 3x3 crosses generate six families, three for each fish used. Two hundred eggs are used to create each family and standardized fertilization methods are employed. Therefore, 400 eggs per female are used in the 2x2 crosses and 600 in the 3x3 crosses. Each single-pair mating of approximately 200 eggs is incubated in its own isolette. If male or female gamete quality is poor, it is readily discerned by this approach, since it allows both males and females to produce zygotes with multiple mates.

**Expectations/Hypotheses**

If domestication does not occur fertility will remain constant. However, under hatchery culture selection for fertility may be relaxed considerably, especially in males. If so, fertility could decrease in both the SH and HC lines, but at a faster rate in the HC line.

**Analytical/Statistical Methods and Issues**

Within years, analysis of variance will be used to compare fertility of individual animals within groups. Over years analysis of covariance will be used on mean fertility to detect trend differences between groups.

**Findings To Date**

Of the pre-hatching mortalities we collected from isolettes in 2004, the vast majority were not fertilized (98% of the SH and 97% of the SN mortalities). Thus, on average only 2-3% died after fertilization. Egg survival to the eyed-egg stage averaged 76% and 86% for hatchery and wild females, respectively. Analysis of temporal trends has not yet been completed

**A12. Adult morphology at spawning (revised 12/21/05)**

**Background and Justification**

Based on earlier work (see expectations/hypotheses), domestication can be expected to cause changes in body shape, especially those aspects of shape that are secondary sexual characteristics

**Location(s)** CESRF and possibly some effort on Naches spawning grounds



<b>Groups Compared</b> WC,HC,SN, SH
<b>Protocol</b>
Collect digitized measurement data from lateral image landmarks on photos of adults. Develop orthogonal variables with which to compare WC, HC, SH, and SN fish. Same fish used for traits A7- A10. Requires holding some SH origin males and females (about 30 pairs) to maturity at hatchery in addition to the SN fish that will be held for S broodstock and the HC fish that will be used for HC broodstock. Data on Naches fish will be collected from carcasses on spawning grounds. Program TPSDig ( <a href="http://life.bio.sunysb.edu/morph/index.html">http://life.bio.sunysb.edu/morph/index.html</a> ) will be used to mark the coordinates of 13 landmarks. These are the same 13 used by Hard et al. (2000): 1) tip of snout, 2) base of skull, 3) anterior dorsal insertion, 4) posterior dorsal insertion, 5) anterior adipose insertion, 6) dorsal caudal insertion, 7) posterior end of body, 8) ventral caudal insertion, 9) posterior anal fin insertion, 10) anterior anal fin insertion, 11) anterior insertion of pelvic, 12) anterior insertion of pectoral, 13) distal tip of maxillary.
<b>Expectations/Hypotheses</b>
If domestication does not occur no changes in morphology will occur. If domestication does occur, we expect secondary sexual characteristics in both sexes to become less pronounced; e.g., reduced kype length, reduced body depth, less fusiform body shape, smaller adipose fins (Webb et al. 1991; Fleming and Gross 1992; Petersson and Jarvi 1993; Petersson et al. 1996; Berejikian et al. 1997; Hard et al. 2000). We would thus expect these types of changes in the S and HC lines, with greater changes in the HC line.
<b>Analytical/Statistical Methods and Issues</b>
Analysis closely follows Hard et al. (2000) and Wessel et al. (2005). Principal and partial warps were generated by TPSRelW. Warp scores were then used in MANOVA, MANCOVA, and discriminant function analysis in Systat to evaluate differences between groups (sexes, origins, and years). TPSRegr was used to regress warp scores on centroid size, and to generate consensus shapes for visual comparison. Use of IMP program Standard6 is being explored as a means of further reducing influence of size on shape.
<b>Progress to Date</b>
Initial analysis showed males to differ significantly from females, hatchery-origin fish of both sexes to differ significantly from natural-origin fish, and Naches fish of both sexes to differ significantly from Upper Yakima fish (Busack et al. 2004). A more in depth comparison of hatchery-origin and natural-origin Upper Yakima fish over three return years revealed significant differences between sexes, origins, and years (Busack et al. 2005), but comparison of shapes revealed digitizing problems at one landmark. Fish have been redigitized and reanalysis is underway. We intend to produce a MS for publication on this work.

<b>A13. Adult spawning behavior</b> (revised 12/21/05)
<b>Background and Justification</b>
A critical assumption associated with supplementation is that hatchery-origin adults possess behavioral traits that allow them to spawn under natural conditions at a level that is comparable to natural-origin fish. Previous work that examined the spawning behavior of wild and first generation hatchery spring Chinook at CESRF showed that hatchery-origin fish were not as successful at producing offspring as wild fish. Such a comparison does not allow the relative importance of environmental and genetic effects to be evaluated. Here the reproductive behavior of first- and second-generation hatchery spring Chinook will be compared. In this instance, the early-life history of the fish will be similar (both will have been reared in a hatchery) and thus any differences observed can be attributed to genetic changes caused by inadvertent domestication. Such differences can also be linked to a single generation of additional exposure to hatchery conditions. Documenting the magnitude of any genetic changes observed will significantly increase our understanding of the biological costs associated with supplementation programs that rely on hatcheries prior to release.

<b>Location</b> Observation stream located at the Cle Elum Supplementation Research Facility
<b>Groups Compared</b> HC and SH
<b>Protocol</b> Homogenous spawning populations consisting of pure SH or HC adults will be introduced into 4.9 m wide by 15.2 m long sections of an observation stream while still in an immature state. An opaque, temporary wall will subdivide each of these sections into two, 2.5 m by 15.2 m subsections. Three pairs of fish will be placed into each subsection and all subsections will be filled on the same day. Fish will be weighed, measured, tagged, and DNA sampled prior to being liberated into their designated locations. Traits measured in females will include total life time in the observation stream (longevity) and egg retention at death. Longevity in males will also be assessed.
<b>Expectations/Hypotheses</b> Second generation hatchery fish are expected to be less competent at spawning than first-generation or SH individuals. Fleming et al (1996) and Fleming et al (2000), for example, found that fifth generation hatchery Atlantic salmon were 20 to 40% less effective than wild cohorts at reproducing under natural conditions. If significant domestication occurs, second generation hatchery females are expected to have shorter life-times and greater egg retentions. Second generation males are also expected to have shorter life-times. Fleming et al. (1996) discovered that hatchery Atlantic salmon males ignored key behavioral signals provided by females as they approached ovi-deposition and consequently their ability to fertilize eggs was severely compromised.
<b>Analytical/Statistical Methods and Issues</b> Both non-parametric and parametric analyses will be utilized. For example, longevity data will be ordinal in nature because of how it is collected and consequently Kruskal-Wallis one-way ANOVAs or Mann-Whitney U tests will be used to examine whether differences exist in the longevity of SH and HC adults. In those instances where the response variable is at the interval or ratio scale, nested ANOVAs will be employed. The fixed treatment in these analyses will be adult type (SH or HC), the first order group would be the year that the experiment was performed, subgroups would be the sections in the observation stream that were used, while the items in the subgroups would be values obtained from the individuals placed into a section. An example of this type of analysis would be egg retention in SH and HC females. The random variable in this case would be the percentage of a female's expected fecundity she retained at death. The expectation would be that HC females would not be as effective at depositing their eggs as SH fish. The Nested ANOVA design would be used to test this expectation after the arc sin square root transformation was used on the raw data.  An analysis was performed to determine the experimental design that would provide the most power to detect differences in spawning behavior between SH and HC fish. The results of this analysis indicated that power would increase if the number of homogenous populations of SH and HC were increased. To accomplish that we have subdivided sections in the observation stream making it possible for six independent spawning populations of SH and HC fish to be evaluated each year. The decision to place three pairs in each of these populations was based on two factors, the need for replication within each population and the effects of instantaneous density on spawning success. If more pairs were placed into each population it is likely that intrasexual competition among the females would become intense enough to prevent some of them from spawning.
<b>Findings To Date</b> The effect of behavioral traits in females on their ability to produce offspring was evaluated in NOR and SH spring Chinook in the observation stream. Of these traits, longevity and redd tenure proved to be the most important. Females that guarded a single redd location produced more offspring than those that were evicted or otherwise abandoned their redd locations. Also a positive relationship was found to exist between how long a female lived and her ability to convert her eggs to offspring. Longevity in this case served as a surrogate for energy reserves, long-lived females apparently have greater stores of energy and therefore can complete tasks like territory acquisition, nest construction, redd development, and post-spawn guarding. The reproductive

success of males was primarily linked to their aggressiveness. Individuals that instigated attacks on rivals were generally more successful at producing offspring than fish expressing lower levels of agonistic behavior. For a complete description of these results see Schroder et al. 2003a, 2003b, 2004, and 2005.

#### **A14. Adult spawning success** (revised 12/21/05)

##### ***Background and Justification***

A significant challenge associated with evaluating salmonid supplementation is comparing the productivity of supplemented and non-supplemented populations. The ISRP and ISAB (2005) suggest comparisons could be accomplished if such populations were placed in a common experimental setting. For the past five years we have simultaneously introduced wild upper Yakima spring Chinook along with first generation hatchery fish in an observation stream and compared their capacities to produce offspring. This was done by performing pedigree analyses on the juveniles produced by these populations via micro-satellite DNA. These analyses estimated the number of offspring each adult fish produced. Differences were observed (see below) but it is unknown what proportion was caused by environmental differences in early life history or by genetic change caused by inadvertent domestication. The only way that we can quantify the effects of potential genetic change caused by exposure to hatchery life is to compare the reproductive success of salmon that have experienced different levels of hatchery exposure. In this case, the reproductive success of SH (first generation hatchery fish) will be compared with HC (second generation hatchery fish). Both types of fish will have experienced similar early life histories. Therefore differences between their capacities to produce offspring will be a reflection of genetic change brought about by hatchery conditions. The results of such an appraisal will provide managers with a way to estimate the genetic costs to recipient populations that are being supplemented by adult fish with varying degrees of hatchery ancestry.

***Location(s)*** Observation stream located at the Cle Elum Supplementation Research Facility

***Groups Compared*** HC and SH

##### ***Protocol***

Homogenous populations consisting of pure SH or HC spring Chinook adults will be introduced into 2.5 m wide by 15.2 m long subsections of an observation stream just prior to becoming mature. Fish will be weighed, measured, tagged, and DNA sampled prior to being liberated into their designated subsections. Three fish of each sex will be placed into each subsection and all subsections will be filled on the same day. The fish in each subsection will be allowed to spawn naturally. An estimate will be made of the fecundity of each female to predict her potential egg deposition (PED) and her actual egg deposition (AED) will be estimated by subtracting any eggs she retained at death from her predicted fecundity. Modified fyke nets with floating live boxes will be installed at the end of every subsection to capture juveniles as they emerge and begin to migrate downstream. The fry traps will be checked daily, the number of fry caught will be counted and 10% of them will be preserved in 100% ethanol for later micro-satellite DNA analyses. At the end of the emergence period, electro-shocking gear and seines will be used to remove any remaining juveniles. A pedigree analysis will be performed using DNA samples from the adults and juveniles to estimate the number of offspring each adult produced. Results from the pedigree assessments will allow us to estimate the egg-to-fry survival rates (both PED and AED) of each female placed into a channel section. The capacity to produce offspring depends on the ability of females to choose appropriate nest sites, to construct and guard their nests, and on the ability of males to successfully match their gamete releases to when a female spawns her eggs. If either sex is unable to complete a specific series of tasks productivity will decrease. That is why we will be looking at two egg-to-fry survival measures. The first one (PED-to-fry survival) is a measure of how successfully a female was able to convert the eggs she brought into a spawning ground to fry. The second one (AED-to-fry survival) looks at how successful the eggs deposited by a female are converted into juveniles.

##### ***Expectations/Hypotheses***

The effects of domestication are expected to increase in cultured populations that have prolonged artificial rearing periods and that are continuously recycled back into a hatchery. Given this

expectation, we hypothesize that the HC populations will be less productive at producing fry than those comprised of SH individuals. The degree of difference will reflect the genetic cost associated with one additional generational exposure to hatchery conditions.

**Analytical/Statistical Methods and Issues**

Mixed model Nested ANOVAs will be used to compare the productivity of HC and SH populations. In these analyses, the fixed treatment will be the adult origin of the population, i.e. SH or HC. The first random group will be year that the experiment was performed, the random subgroup below year will be the subsection in the channel where the population spawned, and the items in that subgroup will be female specific values for either PED-to-fry survival or AED-to-fry survival. The goal is to have three females in each population for all years of the study in an effort to create a balanced design. Thus every subgroup would have three replicate values of either PED or AED survival to the fry stage. This design will reveal how much variation in productivity can be accounted for by channel subsection, year, and adult origin. Even if the channel subsections or years add a significant amount of variation to the analyses, we will still be able to evaluate whether the variation caused by adult origin is greater than expected. Four years of such comparisons are planned. Therefore over the duration of this study, a total of 96 HC and SH males and females will be used (24 males and females of each type per year).

The number of adults that will be placed into each population was based on previous studies in the observation stream from 2000-2005. This work suggests that three spring Chinook females are able to spawn simultaneously in 2.5 m wide x 15.2 m long stream sections. When higher numbers are present, significant intrasexual competition among females for space occurs. In most instances, instantaneous densities of spawning females in supplemented populations will be low. Consequently, three females represent a compromise between the need for replication and the desire to mimic natural spawning densities. Refinements to nested ANOVA designs are based on assessments of how much variation exists in each of the random groups and subgroups. As in the Trait 12A we expect that the most variable portion will be the individual values obtained from the females placed into the observation stream. If necessary, adjustments to the number of fish used in each population will be made after the first study year has been completed. For example, up to six females could be placed into each subsection. However, at these loading densities, a number of females may be prevented from spawning or might only be able to partially spawn. Consequently the desire for replication would actually increase variance and subsequently reduce power.

**Findings To Date**

Beginning in 2001 we created heterogeneous populations of wild- and hatchery-origin spring Chinook and allowed them to spawn naturally in the observation stream. Altogether, seven independent test groups were placed into the stream from 2001 through 2005. No differences were detected in the egg deposition rates of wild and hatchery females ( $P = 0.228$ ). Pedigree assignments based on microsatellite DNA, however, showed that the eggs deposited by wild females survived to the fry stage at a 7% higher rate ( $P = 0.01$ ) than those spawned by hatchery females. Subtle differences between hatchery and wild females in redd abandonment, egg burial, and redd location choice may have been responsible for the difference observed. Body size did not affect the ability of females to spawn or the survival of their deposited eggs. How long a female lived was positively related to her breeding success but female origin did not affect longevity. The density of females spawning in portions of the stream affected both egg deposition and egg-to-fry survival. No difference, however, was found in the overall distribution patterns of the two types of females. We also discovered that reproductive success in males is often twice as variable as that found in females. For example, the coefficient of variation in male success ranged from 90 to 200% whereas for females it varied from 34% to 77%. An analysis examining the importance of male origin and behavior on their ability to produce offspring is ongoing.

**J1. Emergence timing** (revised 12/21/05)

**Background and Justification**

When a juvenile emerges has a direct affect on its potential survival. Therefore rate of

<p>development is subject to strong natural selection pressures. Fish that emerge early will encounter little competition for territorial sites but may experience low food availability. Conversely, late emerging individuals will have to compete with prior residents and may be forced to make lengthy downstream migrations in order to find open habitat areas for rearing. In most production hatcheries fish are not allowed to emerge from their incubation devices. Moreover, when they are introduced into juvenile rearing areas the capacity to find and hold a feeding territory is not relevant. Hence, selection pressures that have finely tuned when natural-origin fish emerge are greatly relaxed in hatcheries. We are uncertain how or whether developmental rate will be affected by domestication. The goal of this evaluation is to determine if exposure to incubation and early rearing conditions in a hatchery will alter the rate that embryos develop into free-swimming fry.</p>
<p><b>Location</b> Cle Elum Supplementation and Research Facility incubation room</p>
<p><b>Groups Compared</b> WC<sub>p</sub>, SH, SH<sub>p</sub>, and HC</p>
<p><b>Protocol</b></p> <p>Compare emergence timing of fish from different groups produced by <i>inter se</i> matings (same matings in trait A10). Eggs will be housed in 100-egg upwelling incubation chambers that allow fish to volitionally exit. Number of fish exiting will be noted daily. Eggs used will be those from the studies of adult reproductive traits.</p>
<p><b>Expectations/Hypotheses</b></p> <p>If domestication does not occur, we would expect no changes in emergence timing or duration of emergence. If domestication does occur, we would expect duration of emergence to be compressed due to the more homogeneous environment presented by the hatchery, however, this trait has not been examined by other investigators so if or how emergence timing may be altered is unknown. If our supposition is correct, the emergence period for HC and SH would be reduced but more so in HC. Also If egg size increases as a result of domestication (see trait A8), then time to emergence will increase in SH and HC, with HC showing a greater increase. This would occur because it takes embryos originating from large eggs longer to develop into fry than those produced by smaller eggs.</p>
<p><b>Analytical/Statistical Methods and Issues</b></p> <p>Two within-year analyses will be performed: 1) a nonparametric or parametric analysis of variance will be used to compare duration of emergence. If egg size and duration are correlated, then analysis of covariance will be used to correct for this factor; 2) analysis of covariance will be used to compare median date of emergence among groups. Over years, analysis of covariance will be used to examine differences in trends in these two variables.</p>
<p><b>Findings To Date</b></p> <p>Results from 2002 and 2003 were reported in Knudsen et al. 2003c and 2004c. However, due to problems with uncontrolled water temperatures during those years we believe our earlier analyses were compromised. Our attempts to control water temperature across vessels using a single mixing head box delivery system have not been completed, yet.</p>

<p><b>J2. K<sub>D</sub> at emergence</b> (revised 12/21/05)</p>
<p><b>Background and Justification</b></p> <p>The amount of yolk reserves a juvenile possess at emergence can affect its survival in two opposing ways. First, yolk material can serve as an important food reserve as an individual transitions from an endogenously feeding fish to one that must rely on external prey. Second, yolk materials may also make an individual conspicuous, reduce its swimming speed, and therefore increase the risk that a predator will consume it (Fresh and Schroder 1987). Therefore, the amount of yolk material a fish has at emergence is likely a compromise between these two competing selection pressures. Under hatchery conditions these pressures will be relaxed and it is uncertain how K<sub>D</sub> will respond. If it changes in either direction negative survival consequences could occur when fish incubate and emerge under natural conditions.</p>

<b>Location</b> Cle Elum Supplementation and Research Facility incubation room
<b>Groups Compared</b> WC <sub>p</sub> , SH, SH <sub>p</sub> , and HC
<b>Protocol</b>
Compare developmental condition at emergence (KD, Bams 1970) of fish from different groups produced by <i>inter se</i> matings (same fish as in J1). Eggs will be housed in 100-egg upwelling incubation chambers that allow fish to volitionally exit. KD will be measured daily on fish as they exit. Eggs used will be those from the studies of adult reproductive traits.
<b>Expectations/Hypotheses</b>
If domestication does not occur, we would expect no changes in KD. If domestication does occur, and egg size increases as a result, we would expect KD to increase. Thus, KD would increase in SH and HC, but more so in HC.
<b>Analytical/Statistical Methods and Issues</b>
Within years analysis of covariance (with egg size as covariate) will be used to compare slopes and adjusted means among groups. Over years, analysis of covariance will be used to examine differences in trends in these two variables.
<b>Findings To Date</b>
There was a significant positive relationship between KD values and egg weight for both SH <sub>p</sub> and SN fry (R <sup>2</sup> >0.42, p<0.001; Knudsen et al. 2003c, 2004c, 2005d). The ANCOVA of KD and Egg weight for 2002, 2003 and 2004 all showed that SH <sub>p</sub> and SN relationships had equal slopes (p>0.26), but significantly different means adjusted for egg weight (p<0.02; Knudsen et al. 2003c, 2004c, 2005d). The differences in KD means are very small and may not be biologically meaningful. However, SH origin samples (KD means ranged from 1.911 to 1.916) were consistently greater than SN samples (KD means ranged from 1.892 to 1.895). F1: KD values of SH <sub>p</sub> (overall mean = 1.98) and SN (overall mean=1.99) fry did not differ significantly (P=0.126) in a 2-way ANOVA testing for Origin and Brood year effects. F2: ANCOVA of BY2006 indicated that KD vs. Egg weight relationships of HC <sub>p</sub> (n=27) and SN (n=26) fry were significantly different (p=0.050). A t-test comparing KD HC <sub>p</sub> (mean =1.968) and SH (mean=1.975) fry was not significant (p=0.598). Analysis of temporal trends has not been completed.

<b>J3. Egg-fry survival</b> (revised 12/21/05)
<b>Background and Justification</b>
Egg-to-fry survival is the culmination of a continuous series of ontological events that depend upon gamete quality. In general, fertilization must occur along with successful hatching and conversion of yolk to body tissues. Natural selection pressures affect eggs and alevins that incubate in nests created by their maternal parent. We assume that these same selection pressures will be muted in a hatchery and that a new set will be imposed. Thus over time adaptations that increase the survival of hatchery fish to their new incubation environment are expected to evolve. As a result survival may increase in a hatchery setting but may decrease under natural conditions.
<b>Location</b> Cle Elum Supplementation and Research Facility incubation room
<b>Groups Compared</b> SH, SH <sub>p</sub> , and HC
<b>Protocol</b>
Compare egg-to-fry survival of fish from different groups produced by <i>inter se</i> matings (same matings in trait A10). Eggs will be housed in 200-egg isolettes (see trait A10). At the eyed-egg stage mortalities in each isolette will be counted. Then 100 live eggs from a sunset of females will be placed into the upwelling chambers described in J-1 and 2. The remaining eggs will be returned to their isolettes and mortality will be assessed at yolk absorption. In addition, mortality will be assessed in the upwelling chambers after emergence has been completed.
<b>Expectations/Hypotheses</b>
If domestication does not occur, we would expect no changes in egg-to-fry survival. If domestication does occur, we would expect survival of HC fish to increase over time as they adapt to hatchery selection pressures during incubation (Reisenbichler and McIntyre 1977).

Survival of SH fish should also increase but not as rapidly as HC and SN fish will show a smaller or no increase.
<b>Analytical/Statistical Methods and Issues</b>
Within years analysis will be conducted by using a one-way ANOVA. The random variable will be percent survival in each isolette. The arc-sin transformation will be used to normalize the data. Analysis of covariance will be used to ascertain if trends in survival diverge over time.
<b>Findings To Date</b>
F1: In 2001, SN <sub>p</sub> fry survived at a significantly higher rate than SH <sub>p</sub> fry (P=0.047), while in 2004 SH <sub>p</sub> fry had significantly higher survival (P=0.023). The other two broodyears were not significantly different (2002 and 2003, P>0.41). Thus, the effects of female origin on fry survival varied significantly across broodyears and showed no consistent trend . F2: Egg-to-fry survival of SN <sub>p</sub> fry (mean survival= 0.677) was approximately the same as HC <sub>p</sub> fry (mean survival= 0.681) for BY2002. Origin effects were not significant (t-test p=0.849). This was the poorest in-hatchery egg-to-fry survival recorded since we began monitoring in 1997 (Knudsen et al. 2007b). Analysis of temporal trends has not been completed.

<b>J4. Occurrence of developmental abnormalities</b> <i>(revised 12/21/05)</i>
<b>Background and Justification</b>
Abnormalities in juvenile salmonids are caused by environmental perturbations as well as by genetic factors such as inbreeding. In theory, the founding populations of hatcheries should be diverse enough to limit inadvertent inbreeding. However, large variances in family size can occur in salmonids and therefore it is possible that genetic diversity can be significantly reduced over time, increasing the likelihood of inbreeding. Here we will monitor the occurrence and type of abnormalities in populations that have experienced differing levels of hatchery exposure. Such an evaluation may allow us to indirectly measure loss of genetic diversity. Conversely, HC fish may be better adapted to the physical conditions experienced during hatchery incubation and therefore express fewer abnormalities than SH embryos.
<b>Location</b> Cle Elum Supplementation and Research Facility incubation room
<b>Groups Compared</b> SH, SH <sub>p</sub> , and HC
<b>Protocol</b>
Compare the percentage of abnormally appearing alevins originating from each group using the progeny produced from the <i>inter se</i> matings (same matings in trait A10). Eggs will be housed in 200-egg isolettes (see trait A10). After yolk absorption abnormal appearing alevins in each isolette will be counted.
<b>Expectations/Hypotheses</b>
If domestication does not occur, we would expect no changes in the occurrence of abnormal fry. If it does occur we may see more or fewer abnormalities in HC fish. More abnormalities would be expected in the HC fish if genetic diversity is reduced and inbreeding heightened (Kincaid 1976). Less would occur if HC fish were adapting to the selection pressures present during the hatchery incubation period. If inbreeding occurs the proportion of abnormal offspring present in the SH and SN groups is also expected to increase but at a lower rate than that expressed by the HC line. Alternatively, fewer abnormalities may be expressed in SH and SN lines over time if the fish are adapting themselves to hatchery incubation conditions. The WC line will not be included in this trait due to the significantly different manner in which eggs are handled post-fertilization which might, through mechanical perturbations, cause developmental abnormalities.
<b>Analytical/Statistical Methods and Issues</b>
Within years analysis will be conducted by using a one-way ANOVA. The random variable will be percent abnormalities in each isolette. The arc-sin transformation will be used to normalize the data. Analysis of covariance will be used to ascertain if trends in percent abnormalities diverge over time.
<b>Findings To Date</b>
Occurrences of abnormalities in emergent fry have been very low (<0.9%; Knudsen et al. in

prep.). In general, no differences were observed in the incidence of abnormalities in offspring produced by SH and SN origin adults in 2002, 2003, and 2004 (Knudsen et al. 2003c, 2004c, 2005d). In 2001, SH values were significantly greater than SN by 0.5% (ANOVA;  $p=0.04$ ; Knudsen et al. 2002). Analysis of temporal trends has not been completed.

## **J5. Fry-smolt survival in a hatchery environment** *(revised 12/21/05)*

### **Background and Justification**

Survival from the unfed fry stage to smolt can be used as a indicator of domestication. Presumably, individuals that originated from hatchery-origin parents should experience higher survival rates in raceways than those originating from natural-origin fish if domestication is occurring.

**Location** Cle Elum Supplementation and Research Facility

**Groups Compared** SH and HC

### **Protocol**

The fry-to-smolt survival of supplementation and hatchery control line fish being reared in a hatchery environment will be compared. HC and SH fish will be reared in separate raceways under comparable conditions (loading densities, feeding rates, water temperatures, flows, etc.). Mortalities will be counted throughout the entire rearing period until volitional release begins. This comparison will not include WC juveniles because there is no intention to raise WC fish to the smolt stage. Raising WC fish to the smolt stage would require additional hatchery facilities and these fish would have to be sacrificed rather than released. Also, taking enough eggs to have sufficient WC fry to fill a raceway at standard rearing densities would have an unacceptably high impact on the Naches population.

### **Expectations/Hypotheses**

If domestication does not occur, we would expect mortality rates to be comparable in the HC and SH groups. If domestication does occur, we would expect HC fish to have lower mortality rates during the rearing period (Reisenbichler and McIntyre 1977).

### **Analytical/Statistical Methods and Issues**

Within years analysis will be conducted by using a one-way ANOVA. The random variable will be percent mortality experienced over the entire rearing period by raceway. The arc-sin transformation will be used to normalize the data. Analysis of covariance will be used to ascertain if trends in mortalities diverge over time. Since at present there are only two HC raceways within year tests will not be statistically robust. However, over time replicates will take place increasing the power of this evaluation.

### **Findings To Date**

Problems associated with bias in fecundity estimates used to estimate the number of initial fry have been resolved and the data are now being analyzed.

## **J6. Juvenile morphology at release** *(revised 12/21/05)*

### **Background and Justification**

Based on earlier work (see expectations/hypotheses), domestication can be expected to cause changes in body shape, especially those aspects of shape that are secondary sexual characteristics, but differences may also be seen in juveniles because shape has heritable components (Hard et al. 1999).

**Location(s)** HC Acclimation site

**Groups Compared** SH, HC

### **Protocol**

Photograph 50 fish from each raceway at acclimation site, for a total of 100HC and 200 SH fish. Collect digitized measurement data from lateral image landmarks on photos. Program TPSDig (<http://life.bio.sunysb.edu/morph/index.html>) will be used to mark the coordinates of 13 landmarks. These are the same 13 used by Hard et al. (2000): 1) tip of snout, 2) base of skull, 3) anterior dorsal insertion, 4) posterior dorsal insertion, 5) anterior adipose insertion, 6) dorsal



caudal insertion, 7) posterior end of body, 8) ventral caudal insertion, 9) posterior anal fin insertion, 10) anterior anal fin insertion, 11) anterior insertion of pelvic, 12) anterior insertion of pectoral, 13) distal tip of maxillary.
<b>Expectations/Hypotheses</b>
If domestication does not occur no changes in morphology will occur. If domestication does occur, SH and HC morphology will diverge. We would expect that HC fish would become more fusiform (Taylor 1986).
<b>Analytical/Statistical Methods and Issues</b>
Analysis will closely follow Hard et al. (2000) and Wessel et al. (2005). Principal and partial warps will be generated by TPSRelW. Warp scores will then be used in MANOVA, MANCOVA, and discriminant function analysis in Systat to evaluate differences between groups (origins and years). TPSRegr will be used to regress warp scores on centroid size, and to generate consensus shapes for visual comparison. Use of IMP program Standard6 is being explored as a means of further reducing influence of size on shape
<b>Findings to Date</b>
Fish have been photographed for two years and digitized, but no analysis has been done yet.

<b>J7. Smolt-to-smolt survival</b> (revised 12/21/05)
<ul style="list-style-type: none"> <li>a) SH and HC from Clark Flats acclimation site to Chandler</li> <li>b) SN, SH and HC from RAMF to Chandler</li> <li>c) SN, SH, HC, WC from Chandler to McNary and John Day dams</li> </ul>
<b>Background and Justification</b>
Survival during the smolt-to-smolt stage can be used as a indicator of domestication. Individuals that originate from hatchery environments are known to experience lower survival rates during freshwater emigration than natural origin smolts. We are monitoring and comparing the survival of hatchery and wild origin smolts in the Yakima River to ascertain the biological cost of hatchery rearing on smolt survival. Quantification of this cost requires that the in-stream survival of fish exposed to varying levels of artificial culture be simultaneously evaluated. Consequently, the survival of SH and HC smolts released from Clark Flats will be measured as they migrate past Chandler, and two lower Columbia River Dams. The survival of SN smolts will also be assessed to provide a relative measure of hatchery smolt quality. If survival rates between HC and SH smolts are comparable then no genetic effect has occurred. Moreover, comparing the survival rates of HC, SH, and SN smolts can whether hatchery conditions affect smolt survival. In this case, if HC and SH survival is relatively low when compared to SN smolts then environmental factors associated with hatchery life are most likely responsible. Obviously, the proportion of naturally spawning hatchery-origin adults in the parental generation could influence the quality of SN smolts. However, WC smolts will not be affected in this manner and will thus serve as wild controls.
<b>Location</b> Clark Flat Acclimation site, RAMF, Chandler, McNary and John Day dams
<b>Groups Compared</b> <ul style="list-style-type: none"> <li>a) HC and SH from Clark Flats</li> <li>b) SN, SH, HC from RAMF to Chandler, McNary, and John Day Dams</li> <li>c) SH, HC, SN, and WC from Chandler to McNary and John Day Dams</li> </ul>
<b>Protocol</b>
<ul style="list-style-type: none"> <li>a) HC and SH pre-smolts reared at Clark Flats will receive PIT tags prior to being released. PIT tag detectors will monitor their passage through Chandler, McNary, and John Day dams. Tag recovery will be downloaded and analyzed to compare the survival rates of HC and SH smolts.</li> <li>b) A sub-sample of SN, SH, and HC fish will receive PIT tags at Roza (RAMF). Survival rate comparisons of SN, SH, and HC fish will only occur among individuals that passed through the Roza juvenile trap during the same time period. WC smolts do not migrate past the RAMF and therefore will not be included in this analysis.</li> <li>c) Additional fish will be tagged at Chandler, including Naches and American smolts (identified by DNA micro-satellites). Comparisons of survival rates among these fish will be based on PIT tag recoveries at monitoring sites located at McNary, John Day, and any other suitably equipped downstream sites.</li> </ul>

<b><i>Expectations/Hypotheses</i></b>
If domestication does not occur, we would expect smolt-to-smolt survivals of HC and SH groups to be comparable. SN fish are expected to survive at higher rates. This phenomenon has been observed in many other salmonid populations. If domestication does occur, we would expect SH smolts to survive at higher rates than HC individuals, but not as well as SN fish. The comparisons involving SN need to be interpreted carefully, because they include only SN fish that migrate during the spring. Winter migrants, another major life history strategy, will not be included. The survival of WC smolts is expected to be free of hatchery influence.
<b><i>Analytical/Statistical Methods and Issues</i></b>
Within-year analyses will be performed by using logistic regression analysis. Analysis of covariance will be used to ascertain if trends in survival diverge over time.
<b><i>Findings To Date</i></b>
None.

<b>J8. Natural Smolt Production</b> <i>(revised 12/21/05)</i>
<b>Background and Justification</b>
Smolt productivity, which we define as the number of smolts produced per female spawner, is being monitored to evaluate the effect of supplementation on the Upper Yakima spring Chinook population. Smolt productivity values from Naches and the American River are expected to remain relatively constant over time after adjusting for spawner densities. It is unknown what effect supplementation will have on the smolt productivity level of females spawning in the upper Yakima River. Varying proportions of hatchery-origin females will be spawning in this area. If they are less capable of producing smolts productivity of the whole population will decline. On the other hand, if hatchery females can produce smolts at the same rate as wild cohorts then the productivity of this population segment will remain constant.
<b>Location</b> Chandler Smolt Facility
<b>Groups Compared</b> WC, SN, SH, and HC
<b>Protocol</b>
Out-migrating smolts made up of a mixture of WC, SN, SH and HC fish will be sub-sampled as they migrate past the Chandler facility. These samples will be used to estimate the proportion of smolts that have originated from each of these groups. Marks and tags will be used to identify hatchery-origin fish. DNA samples will be collected on unmarked individuals and used to estimate the proportion of smolts produced by the American River, Naches River and upper Yakima populations. Chinook smolts migrate past Chandler year around, however spring Chinook typically migrate by this facility from March through June. Samples proportionate to smolt abundance will be collected during this period. Total smolt passage numbers will be estimated during the trapping period and allocated to each group based on the results of the DNA analyses and mark recoveries. These estimates will be summed across the migration period to get indices of total smolt production for the WC, SN, SH and HC groups.
<b><i>Expectations/Hypotheses</i></b>
If domestication does not occur, we would expect the density adjusted productivity of the upper Yakima population to remain constant. If domestication does occur, we would expect the productivity of that population to decline over time. And the rate of decline would be positively linked to the prevalence of naturally spawning SH fish in the upper Yakima. The density-adjusted productivity of the WC population will remain constant and it will be used as a wild control benchmark against which the productivity of the upper Yakima population will be compared.
<b><i>Analytical/Statistical Methods and Issues</i></b>
Within year analysis will consist of comparing the density-adjusted productivities of each population. This will require that an estimate be made of the total number of smolts produced per population. In addition we need to know how many females produced those smolts. The annual density of female spawners and the proportion of SH females spawning in the upper Yakima will need to be accounted for to help explain variation in productivity. The adjusted smolts/female values will be analyzed with ANCOVA to determine trends in productivity over time. The

relationship between the number of spawning females versus the number of smolts/spawner will be used to describe the density-dependent productivity function for each group.

**Findings To Date**

**No data have yet been collected for this trait**

**J9. Smolt-to-adult survival of hatchery-origin fish** (revised 12/21/05)

**Background and Justification**

Previous studies (Fleming and Petersson 2001; Fleming et al. 1996; Fleming et al.1997; Fleming et al. 2000) have shown that populations that have been repeatedly recycled through a hatchery are more likely suffer from inadvertent domestication than those that have not been continuously exposed to hatchery conditions. Moreover, salmonids with prolonged hatchery rearing periods are more likely to undergo domestication than those that are reared for shorter periods. Because spring Chinook are kept in culture for over a year they may be susceptible to inadvertent domestication, particularly if they are continuously recycled back into a hatchery environment. In this trait, we examine whether the smolt-to-adult survival of HC fish differs from SH individuals. Any difference detected will reflect a genetic change caused by hatchery exposure as both populations will have been incubated and reared in comparable hatchery environments prior to release into the upper Yakima River.

**Location** Clark Flat Acclimation Site to RAMF

**Groups Compared** SH and HC

**Protocol**

Prior to release, every SH and HC fish will be tagged so that its origin can be identified. An estimate of the number of smolts leaving each raceway will be made via continuous PIT tag monitoring. The numbers of adult fish produced from each raceway returning to Roza will be recorded by inspecting fish for tags and marks. Scale samples will be taken to assign an age to each returning adult. The survival of fish by age class will be calculated for each raceway by broodyear. This will be done by dividing the number of 3, 4, or 5 year-olds originating from a raceway/broodyear combination by the total number of fish released from that raceway. WC fish will not be included for reasons outlined under J5.

**Expectations/Hypotheses**

If domestication does not occur, we would expect HC and SH fish to have equivalent survival rates. If domestication does occur, we would expect SH-origin fish to have higher survivals than HC individuals.

**Analytical/Statistical Methods and Issues**

Differences in overall survival will be examined by using a mixed model two-way ANOVA. The fixed treatment will be smolt origin, either HC or SH, and the random treatment will be brood year. The random variable in this ANOVA will be the percentage of smolts that survived to the adult stage. Additional mixed model two-way ANOVAs will be performed to see if age at maturation varied due to smolt origin. In these analyses, smolt type (HC or SH) will be fixed and brood year will once again be a random treatment. The response variable will be the percentage of smolts that matured at a given age within the same sex. For example, one of these ANOVAs would compare the percentage of 3-yr-old males produced by the HC and SH lines. These tests will not only allow us to examine whether shifts in age at maturation are occurring due to domestication they may also help explain any differences seen in overall survival. Finally, ANCOVA will be used to ascertain if trends in survival by age in HC and SH fish diverge over time.

**Findings To Date**

Analyses on this trait have not yet started. The first 3-year-old HC adults returned to the upper Yakima in 2005. Consequently it won't be until 2007 before the first broodyear to produce HC fish will have completed its return back to the Yakima.

**J10. Smolt out-migration timing and rate** (revised 12/21/05)

<b>Background and Justification</b>
Both exogenous and endogenous factors regulate the onset and duration of seaward migrations in natural origin smolts (Groot 1982). Chief among the endogenous factors would be an increase in hypo-osmotic regulatory capacity, elevated levels of thyroxine, and hormones regulating growth (Folmar and Dickhoff 1981). Important exogenous factors would include water temperature, day length, and lunar phases during the spring (Grau et al. 1981). Clearly, the temporal occurrence and speed of downstream migration can have significant survival effects on juvenile salmonids (Hoar 1976). One concern associated with artificial rearing has been whether exogenous cues are obscured by hatchery conditions. For example, facilities that use spring water are likely denying their fish the opportunity to detect seasonal changes in water temperature. This could affect the timing of smoltification and their readiness to migrate. Here we compare the timing and speed of migration of smolts originating from three different sources. Two of these will be hatchery-origin fish that have different levels of hatchery exposure (HC and SH lines). The third group represents individuals that have been produced under natural conditions, the SN line.
<b>Location</b> From the Clark Flat Acclimation site to downstream monitoring sites
<b>Groups Compared</b> SN, SH, and HC
<b>Protocol</b>
Two comparisons of migration speed will be made. In the first, a sub-sample of SN, SH, and HC fish will receive PIT tags as they are collected at the Roza juvenile trap. Their subsequent migration rates past downstream sampling locations will be compared. Furthermore, to account for probable differences in migration speed due to seasonal effects, comparisons will be restricted to individuals that passed through the Roza juvenile trap during the same time period. In the second comparison, migration speeds of HC and SH fish will be made that include all PIT tagged fish released from the Clark Flat acclimation site. The timing and abundance of these fish as they move downstream past Roza, Chandler, McNary, and John Day dams will be recorded and compared. Migration timing of SN, SH, and HC smolts will be evaluated by documenting their temporal occurrence and abundance at the Roza Adult Monitoring Facility. WC fish will not be included for reasons outlined under J5.
<b>Expectations/Hypotheses</b>
If domestication does not occur, HC and SH fish are expected to migrate at the same time and rate. If it does occur, we are uncertain what effect it might have. However, since both HC and SH fish will experience comparable juvenile histories it will be possible to assign any discovered difference to additional exposure to hatchery conditions. In the first migration rate comparison, HC, SH, and SN smolts are expected to migrate at equivalent rates because they all are actively migrating smolts. However, hatchery conditions may delay smoltification or create differences in morphology and energy reserves that could cause HC and SH smolts to migrate at slower speeds than SN fish. Currently, it is unknown whether the migration timing of SH and HC fish will be influenced by the rearing and release protocols they experience. We are evaluating this trait because of its close linkage to smolt-to-adult survival. Thus, if timing differences are noted they may help explain any differences seen in the survival rates of SN, SH, and HC smolts to the adult stage.
<b>Analytical/Statistical Methods and Issues</b>
Within year analysis of migration speed and timing will use Kolmogorov-Smirnov tests. Analysis of covariance will be used to ascertain if genetically based trends in median out-migration timing occur in HC and SH fish.
<b>Findings To Date</b>
None, study will begin in 2006

<b>J11. Food conversion efficiency</b> (revised 12/21/05)
<b>Background and Justification</b>
As fish become adapted to the hatchery environment, one aspect of adaptation may be the ability to more efficiently metabolize the artificial feeds used in the hatchery
<b>Location(s)</b> Cle Elum Supplementation and Research Facility and smolt acclimation sites

<b>Groups Compared</b> SH and HC
<b>Protocol</b>
This trait is a surrogate for growth rate. HC and SH fish will experience normal hatchery rearing procedures, which includes being fed at a rate based on size. The quantity of food supplied to each raceway from ponding to release will be recorded. Two random samples of fish will be removed from each raceway, one at the time of tagging (after 8 months of rearing) and another just prior to release (approximately 12 months of rearing). Individual weights will be taken on 200 fish from each raceway. The weight data will be used to estimate the biomass of fish in each raceway at the time of sampling. Food conversion efficiencies will be determined by dividing total biomass of fish by total weight of food delivered to a raceway. WC fish will not be included for reasons outlined under J5.
<b>Expectations/Hypotheses</b>
If domestication does not occur, we would expect HC and SH fish to have equivalent food conversion rates at tagging and again just prior to release. If domestication does occur, we would expect HC fish to have greater food conversion efficiencies than SH fish (Reisenbichler, pers. comm.).
<b>Analytical/Statistical Methods and Issues</b>
Within year analyses will use one-way ANOVAs (per sample period) to examine food conversion rates in HC and SH raceways. A single within year analysis will have low power because there are only two HC raceways. However, by analyzing multiple years with two-way ANOVAs power will be increased, allowing us to examine year and treatment effects. Within-year analyses of conversion rate will be done by two-way fixed treatment ANOVAs estimating origin, raceway, and interaction effects. In addition, analysis of covariance will be used to ascertain if trends in food conversion in these two groups diverge over time. With only one measurement per raceway, and only two HC raceways, this is not a powerful design, so it may well be dropped in the future.
<b>Findings to Date</b>
Data are available, but have not yet been analyzed.

<b>J12. Juvenile Length-Weight Relationships</b> <i>(revised 12/21/05)</i>
<i>Background and Justification</i>
Multiple-generational exposure to hatchery conditions is expected to modify traits in juvenile salmonids, making them better adapted to artificial rearing conditions. One potential adaptation would be an increased capacity to convert artificial foods into biomass. Such a difference could be expressed by possessing a more robust body shape (greater weight for a given length). Since the groups being compared will be HC and SH fish any differences seen are likely to be genetically based and thus trait can be another measure of domestication.
<b>Location</b> CESRF and smolt acclimation sites
<b>Groups Compared</b> SH and HC
<b>Protocol</b>
HC and SH fish will experience normal hatchery rearing procedures. Two random samples of fish will be removed from each raceway, one at the time of tagging (after 8 months of rearing) and another just prior to release (after approximately 12 months of rearing). Individual lengths and weights will be taken on 200 fish from each raceway. WC fish will not be included for reasons outlined under J5.
<b>Expectations/Hypotheses</b>
If domestication does not occur, we would expect HC and SH fish to have equivalent length/weight relationships at tagging and again just prior to release. If domestication does occur, we would expect HC fish to either have steeper slopes (greater biomass increase per unit length) than SH fish or greater mean body weight at a standardized length.
<b>Analytical/Statistical Methods and Issues</b>
Within year analyses will compare the length/weight relationships found in SH and HC juveniles by using ANCOVA. In addition, analysis of covariance will be used to ascertain if trends in mean

length and weight in these two groups diverge over time.

**Findings To Date**

F<sub>1</sub>: ANCOVA using egg mass as a covariate showed that SH<sub>p</sub> fry were significantly ( $P=0.002$ ) heavier (mean body weight across all years = 317 mg) than SN<sub>p</sub> fry (mean body weight across all years = 313 mg) in each of the four years.

F<sub>2</sub>: We tested for Origin effects in BY2002 fry body weight distributions by ANCOVA using egg mass as a covariate. HC<sub>p</sub> fry (mean body weight = 300 mg) were slightly smaller than SN<sub>p</sub> fry (mean body weight 304 mg), but there was no significant Origin effect ( $p=0.209$ ) indicating that, given eggs of the same weight, hatchery fry will have equivalent body mass as wild fry in 2006 (Knudsen et al. 2007b).

**J13. Agonistic-competitive behavior** (revised 12/21/05)

- a) Contest competition
- b) Scramble competition
- c) Aggression

**Background and Justification**

*Competition and aggression has been demonstrated to be influenced by domestication*

**Location(s)** Cle Elum Supplementation and Research Facility

**Groups Compared** WC<sub>p</sub>, SH, and HC

**Protocol**

Juvenile fish produced from the crosses used in J3 will be test subjects. Dominance and aggressiveness will be compared to the WC<sub>p</sub>. Two types of dominance experiments will be performed. The first will test for contest competition (14a) and the second scramble competition (14b). In this behavioral assay, three group comparisons will be made: WC<sub>p</sub> vs. HC, WC<sub>p</sub> vs. SH, and SH vs. HC. Size-matched pairs of fish (each fish represents a different group) will be simultaneously introduced into tanks. In the test of contest competition, fish will be placed into tanks that have one optimal location (possessing one piece of cover and a single tube used to introduce food and velocity in the water column). Dominance will be assigned to the fish that obtains the most food, dominates the majority of the agonistic contests, and spends the most time adjacent to the food tube and cover. In the test of scramble competition, no cover will be provided, water will be introduced through a tube as before, and food will be introduced in different locations on the surface of the water. Dominance will be assigned to the fish that eats the most food items. Replicate trials will be conducted for 7 days. Aggression (14c) will be examined by comparing the rates of agonistic interactions initiated during competition trials in 14a and 14b. In the event that the desired number of replicates cannot be achieved, then contest competition will be prioritized over scramble competition. Approximately 250 trials will be conducted every year.

**Expectations/Hypotheses**

If domestication does not occur, we would expect HC, WC<sub>p</sub>, and SH fish to have equivalent levels of aggression and dominance. If domestication does occur, we would expect the following results ordered from most to least: contest competition dominance WC<sub>p</sub> >SH>HC; scramble competition dominance HC>SH>WC; and aggressiveness WC<sub>p</sub> >SH>HC or HC>SH> WC<sub>p</sub>. In addition, we would expect that these differences would be accentuated with time. How aggressive and dominant WC<sub>p</sub> fish may be is unknown, but their behavior is not expected to change over time and therefore they will act as a valuable reference.

**Analytical/Statistical Methods and Issues**

Within a year paired comparisons between hatchery and wild fish of the percentages of food pellets eaten in the water column, fish in the best habitat, interactions initiated, agonistic interactions dominated, interaction type, and overall dominance will be made for each replicate using a two-tailed Wilcoxon matched pairs test. The test for total dominance in the contest trials will be a matched comparison of the sums of the percentages of the food acquisition, habitat

used, and interactions initiated. Paired comparisons of growth and interaction rate (average interactions per minute for all tanks) will be compared using a two-tailed paired student's t-test. A paired sign test will be used to compare whether fish in each replicate that grew the most were also classified as dominant. Analysis of covariance will be used to ascertain if trends in dominance among the comparisons diverge over time.

**Findings to Date**

Offspring of wild origin fish dominated 4% more contests than offspring of hatchery origin fish ( $P < 0.05$ ). Dominance was not significantly different in the scramble competition trials ( $P > 0.05$ ). Wild fish initiated more agonistic interactions than hatchery fish in both contest and scramble trials. There were no differences in the frequency of different types of agonistic interactions that were used by hatchery and wild fish. We also found that dominant fish grew more than subordinate fish in both contest and scramble trials ( $P < 0.05$ ). Detailed descriptions can be found in Pearsons et al. (2004 and 2005).

**J14. Predator avoidance** (revised 12/21/05)

**Background and Justification**

Predation has been demonstrated to be influenced by domestication

**Location(s)** Cle Elum Supplementation and Research Facility

**Groups Compared** WC<sub>p</sub>, SH, and HC

**Protocol**

Predator challenges will be conducted in net pens to determine if domestication affects the survival of fry. To avoid pseudo-replication, multiple arenas possessing different individual fish predators will be established. There will be 8 arenas, which will consist of 8 x 10 foot net pens. Net pens will be placed in a single hatchery raceway. Between 67 (3 line comparison) and 100 (2 line comparison) size-matched fish from each line will be simultaneously introduced into an arena containing 2 rainbow trout and 2 torrent sculpin predators. Prior to introduction, fish from each line will be differentially marked or tagged. After a designated period of time has elapsed, which corresponds to approximately 50% of the introduced fish having been eaten (e.g., 4 days), survivors will be removed from each arena and enumerated. Fish predators will be changed after each trial to avoid pseudo-replication. We will also attempt to measure differences in innate antipredator behaviors between the groups. Behaviors will be assessed in aquaria described for J15, but torrent sculpin predators will be introduced along with the chinook salmon.

**Expectations/Hypotheses**

If domestication does not occur, we would expect fish from all lines to survive at equal rates. In addition, the expression and use of innate anti-predator behaviors should remain constant within a line over time. If domestication does occur, we would expect WC fish to have the highest survival rates followed by SH, and HC individuals in that order.

**Analytical/Statistical Methods and Issues**

Wilcoxon matched pairs tests will be used for within year analyses between SH and HC. For years when WC are available, Wilcoxon matched paired tests will be used between SH and WC and between HC and WC, using WC as a baseline to measure differences in SH and HC survival within year. Analysis of covariance will be used to determine if trends in survival are manifested over time in both assays.

**Findings to Date**

There was no significant difference in survival between the SH and HC fry during 2003 ( $P = 0.051$ ) or 2004 ( $P = 0.122$ ). SH fry were found to have a 2.15% survival advantage over HC fry when 2003 and 2004 data were combined to increase statistical power ( $P = 0.016$ ). Detailed description can be found in Pearsons et al. (2004 and 2005). Trials for the 3-line comparison were conducted in 2005 and results will be available in the spring of 2006.

**J15. Incidence of precocity in production raceways** (revised 12/21/05)

<b>Background and Justification</b>
Larsen et al. (2004) observed that 37 to 49% of the males released from CESRF acclimation sites had matured precociously. They felt this was caused by early rapid growth interacting with a genetic proclivity to mature early. Precocious males are not used as hatchery broodstock therefore if precocious development has a genetic basis it should decrease when a population is repeatedly exposed to a hatchery environment. The occurrence of precocious males in HC and SH fish will be compared to see if this expectation is realized.
<b>Location(s)</b> Clark Flat Acclimation site
<b>Groups Compared</b> SH and HC
<b>Protocol</b>
Just prior to release, two hundred fish from the six raceways located at an acclimation site will be examined to determine the percentage of the males that are precociously maturing. One acclimation site is being used because there are only two raceways of HC fish. Additionally, by using one acclimation site the environmental conditions the fish experience will be standardized. WC fish will not be included as none will be reared in raceways, for reasons mentioned earlier.
<b>Expectations/Hypotheses</b>
If domestication does not occur, we would expect HC and SH fish to have equivalent rates of precocial development. If domestication does occur, we would expect HC fish to have a lower incidence of precocialism.
<b>Analytical/Statistical Methods and Issues</b>
Within year analysis will use one-way ANOVAs. Analysis of covariance will be used to ascertain if trends in the production of precocial males in these two lines diverge over time
<b>Findings to Date</b>
Mean precocity rates of male progeny from first generation hatchery parents were 14% (brood year 2002) and 11% (brood year 2003). Mean precocity rates of male progeny for natural origin parents were 40% (brood year 2002) and 21% (brood year 2003).

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