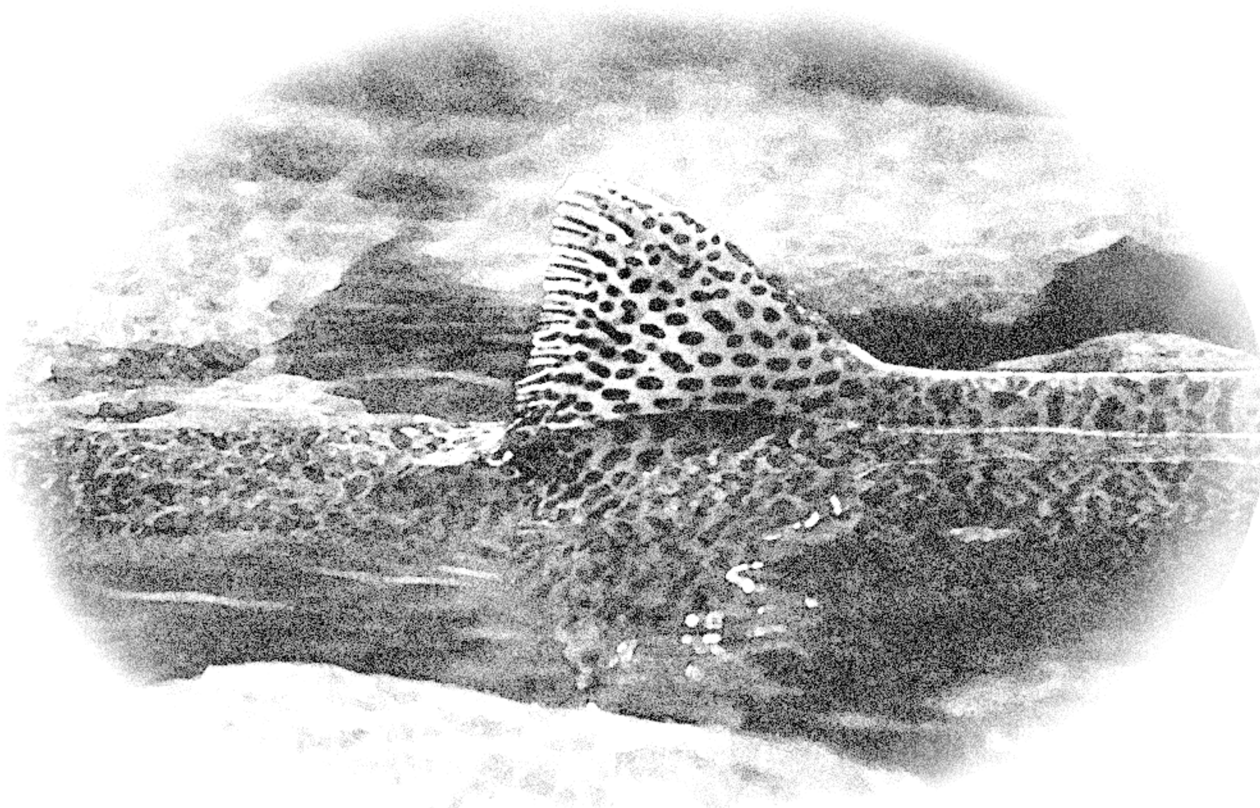
Monitoring and Evaluation Plan
For
Northeast Oregon Hatchery
Imnaha and Grande Ronde Subbasin
Spring Chinook Salmon



Confederated Tribes of the Umatilla Indian Reservation

NEZ PERCE TRIBE TREATY OF 1855

OREGON Fish & Wildlife

LOWER SNAKE RIVER COMPENSATION PLAN

Bonneville Power Administration

Monitoring and Evaluation Plan
for
Northeast Oregon Hatchery
Imnaha and Grande Ronde Subbasin
Spring Chinook Salmon

Prepared by:

Jay A. Hesse
James R. Harbeck

Nez Perce Tribe
Department of Fisheries Resources Management
P.O. Box 365
Lapwai, Idaho 83540

Richard W. Carmichael

Oregon Department of Fish and Wildlife
211 Inlow Hall, Eastern Oregon University
La Grande, Oregon 97850

Contributors:
Steve Boe, Peter Cleary, Craig Contour, Tim Hoffnagle, Saang-Yoon Hyun, Brain Jonasson, Patrick Keniry, Bill Knox, Jerry Lockhart, Paul Moran, Joseph Oatman, Sam Onjukka, Jim Ruzycki, Rishi Sharma, Brad Smith, Erik Tinus, and Jason Vogel.

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621 Portland, Oregon 97208-3621
Project Number 198805301
Contract Number 4034

March 10, 2006

EXECUTIVE SUMMARY

Chinook salmon (*Oncorhynchus tshawytscha*) serve as a powerful cultural and social symbol for tribal and non-tribal people of the Pacific Northwest. Yet despite the significance of this icon, there have been widespread and dramatic declines in Chinook salmon populations over the last century. These declines have also been witnessed in the salmon populations of northeast Oregon. In response, co-managers of this resource have used several management strategies to help reverse the decline including the use of supplementation.

The Northeast Oregon Hatchery (NEOH) program is an effort by co-managers to increase the effectiveness of supplementation and compensation to northeast Oregon spring/summer Chinook salmon populations while minimizing adverse ecological effects. As have many entities, we have adopted the definition of supplementation developed by the Regional Assessment of Supplementation Project (RASP):

> *"Supplementation is the attempt to use artificial propagation to maintain or increase natural production while maintaining the long term fitness of the target population, and while keeping the ecological and genetic impacts on non-target populations within specific biological limits"*

This document describes a monitoring and evaluation (M&E) plan that will allow co-managers to determine whether they are successful in meeting management goals and objectives. It is, therefore, intended to guide evaluation of the NEOH program, give empirical evidence of effects and fill knowledge gaps regarding supplementation and its uncertainty as an enhancement tool. Program success will be gauged primarily by changes in abundance, productivity, diversity and distribution of the supplemented populations, the performance of the hatchery fish relative to their natural counterparts, impacts to non-target populations, and the restoration of tribal and recreational fisheries.

Prior to the detailed methodology sections, the plan provides a brief status review of the Imnaha and Grand Ronde Chinook salmon populations, an overview of the NEOH production program and a description of our approach to monitoring and evaluation. Researchers from northeast Oregon have relied on numerous contemporary documents to develop a plan that (1) coordinates an array of monitoring and evaluation activities, (2) fits within a regional framework, and (3) results in information with broad applicability. The plan also drew from federal, state, tribal, academic and independent sources for monitoring and evaluation recommendations and statistical council.

In addition, researchers took direction for monitoring and evaluation from the goals and objectives of our management and policy people. The basis for many of the monitoring and evaluation activities in the plan followed the NEOH management objectives listed below:

> Management Objective 1: Maintain and enhance natural production in supplemented spring Chinook salmon populations in the Imnaha and Grande Ronde river subbasins.
>
> Management Objective 2: Maintain life history characteristics and genetic diversity in supplemented and unsupplemented spring Chinook salmon populations in the Imnaha and Grande Ronde river subbasins.
>
> Management Objective 3: Operate the hatchery program so that life history characteristics and genetic diversity of hatchery fish mimic natural fish.
>
> Management Objective 4: Keep impacts of hatchery program on non-target spring Chinook salmon populations within acceptable limits.
>
> Management Objective 5: Restore and maintain treaty-reserved tribal and recreational fisheries.
>
> Management Objective 6: Operate the hatchery programs to achieve optimal production effectiveness while meeting priority management objectives for natural production enhancement, diversity, harvest, impacts to non-target populations.
>
> Management Objective 7: Understand the current status and trends of spring Chinook salmon natural populations and their habitats in the Imnaha and Grande Ronde river subbasins.
>
> Management Objective 8: Coordinate monitoring and evaluation activities and communicate program findings to resource managers.

According to the ISAB (2003), the value of a monitoring and evaluation plan is greatly enhanced if different types of monitoring are integrated. Our experimental design represents three monitoring and evaluation approaches integrated at various spatial scales for what co-managers believe is a comprehensive assessment strategy. A combination of population status monitoring, comparative performance testing, and small-scale experiments will be implemented by co-managers in the Imnaha and Grande Ronde subbasins.

Status monitoring will describe existing conditions and provide evidence of trend over time. The NOAA Fisheries RME Plan (2002) calls for status monitoring to document progress toward recovery of listed populations. Repeated measurements are taken over time to quantify change and track trends. This type of monitoring will provide information regarding key attributes for the supplemented natural populations, the reference populations and the greater metapopulations of northeast Oregon.

We also propose to collect performance measure data that will be useful in describing differences or similarities between two or more groups of fish. Comparative performance testing, sometimes called effectiveness monitoring, will occur primarily within and among individual streams. Paired comparisons will be tested at multiple life stages and involve treatment vs. natural, treatment vs. reference, and treatment vs. treatment analysis. Relative performance across streams will be examined for both hatchery and natural production groups. In the absence of replication, it is difficult to assign significance to observed differences between experimental groups. In addition, co-managers recognize that the ability to statistically attribute cause and effect will be somewhat limited due to highly variable environmental conditions (ISRP 2003). Therefore, primary replication will occur across years within a facility or a stream. Results that describe the effectiveness of management actions will involve inference gained by replicated results. Comparative experimental designs that co-managers believe will prove useful are repeated measure designs (Before /After and Treatment vs. Reference) with the addition of small scale studies.

Our efforts will focus primarily on the larger scale M&E activities involved with status monitoring and comparative performance testing. However, additional small scale or short-term studies will be conducted to examine specific issues that require certain study design attributes. Small-scale manipulation experiments can provide a way of isolating the effects of a few important ecological processes from more complex ecological interactions (Peterman 1990). These types of small-scale experiments are research oriented and thus fit the classical hypothesis-testing format (i.e. reproductive success studies using DNA parentage analysis, isolated adult spawning behavior and performance or feed study to reduce jacking in hatchery fish).

Because the variability of an ecosystem occurs at multiple spatial scales and management actions also often occur on different scales, it is necessary to monitor at different spatial scales. Therefore, our monitoring will be varied and dependent on the area of interest and its scope. For consistency's sake, we have categorized our monitoring spatial scales based on Jordan et al. (2002) which is consitent with recent Interior Columbia Technical Recovery Team populations and Major Population Groups (ICTRT 2005).

Based on management questions and assumptions, underlying M&E objectives are proposed to assess the results of the supplementation efforts so that operations can be adaptively managed. We organized the methodology section of the plan according to M&E objectives relevant to the objectives of our managers. Hypotheses, statistical tests, sampling scale and duration and data collection methods are described for each objective. These M&E objectives require quantifiable measures that will describe structural and functional attributes of interest as well as progress toward meeting the objective. Performance measures that are currently being monitored or are proposed to be monitored are presented in Table ES-1. The products from quantified performance measures are diverse. Taken together, these performance measures will provide reliable indicators of change or difference between and among Chinook salmon populations in northeast Oregon.

The final section of the plan discusses program coverage and prioritization and activities necessary to support monitoring and evaluation. Specific facility designs associated with the monitoring and evaluation program are also described that provide for adult interrogation, juvenile marking and treatment group segregation and replication.

A multi-faceted monitoring program has always been part of the natural and hatchery production assessment in northeast Oregon. With many of the data collection activities already being accomplished under multiple independent projects, one role of the NEOH M&E program will be to organize, integrate and prioritize ongoing and new work. Co-managers believe the full suite of performance measures identified below would give managers and policy personnel the scientific information and feedback required to assess the ecological and recovery benefits of the NEOH production program for the Chinook salmon populations of the Imnaha and Grande Ronde subbasins. However, resources required to fully implement the plan may exceed those available to co-managers. Therefore, we assign the highest priority to performance measures associated with population abundance and productivity. Genetic and life history measures also rank high in co-managers prioritization scheme. The adequacy and prioritization of certain performance measures should be periodically reassessed as data and new information becomes available.

A monitoring and evaluation program, such as the NEOH M&E Plan, will result in the collection of extremely valuable data given society's monetary investment and the important management questions to be answered. Hence, the volume and complexity of information gathered through the NEOH M&E Plan will need to be compiled and organized in a systematic manner. It will involve archiving monitoring data, integrating data from different co-manager M&E activities, and making the data accessible. For these reasons it is imperative that data management receive careful attention.

Web sites maintained by the LSRCP program and the NEOH project will be expanded to house NEOH primary databases used cooperatively by NEOH co-managers including; key performance measures database, meta-data descriptions, and documents/reports. Appropriate components of program data and results will continue to be provided to the Pacific States Marine Fisheries Commission (PSMFC) websites including StreamNet, PIT Tag Information System (PTAGIS), and the Regional Mark Information System (RMIS). Fish production and release summaries including mark applications will be provided to the Fish Passage Center web site database.

Finally, this document should be viewed as a living tool that describes the scope of research, the approach towards monitoring and evaluation efforts, and the existence of ongoing research, monitoring and evaluation projects and their relationship to the NEOH program. As such, the associated methods to accomplish the priority objectives are subject to modification as critical uncertainties are addressed, new technology is developed and new questions arise. We also desire to be consistent and coordinated with other regional monitoring and evaluation plans and subbasin planning recommendations.

Table ES -1. Northeast Oregon Hatchery Spring/summer Chinook salmon Monitoring and Evaluation Objectives supported by performance measure and location are referenced by number. Underlined numbers signify key response variables. Methods Description column provides reference number linkage to full monitoring and evaluation plan.

		Imnaha Subbasin			Grande Ronde Subbasin											SFSR	MFSR	
	Performance Measure	Imnaha Subbasin	Imnaha River		Grande Ronde Subbasin	Wenaha River	Lostine River		Minam River	Lookingglass Creek		Catherine Creek		Upper Grande Ronde River		Secesh River	Marsh Creek	Methods Description
	Origin		Nat	Hat		Wild	Nat	Hat	Wild	Nat	Hat	Nat	Hat	Nat	Hat	Wild	Wild	
Abundance	Adult Escapement to Snake Basin																	
	Adult Abundance to Tributary	7c	1a, 1b, 1d, 6b, 7c	1a, 1b, 6b	7c	1d, 7c	1a, 1b, 1d, 6b, 7c	1a, 1b, 6b	1d, 7c	1a, 6b, 7c	1a, 6b	1a, 1b, 1d, 6b, 7c	1a, 1b, 6b	1a, 1b, 1d, 6b, 7c	1a, 1b, 6b	1d	1d	1.a.1 1.d.12
	Fish per Redd Estimate		1a, 1d	1a		1d	1a, 1d	1a	1d	1a	1a	1a, 1d	1a	1a, 1d	1a	1d	1d	1.a.3
	Index of Spawner Abundance - redd counts	7c	1a, 1d, 7c	1a	7c	1d, 7c	1a, 1d, 7c	1a	7c	1a, 7c	1a	1a, 1d, 7c	1a	1a, 1d, 7c	1a	1d	1d	1.a.2
	Spawner Abundance		1a, 1d	1a		1d	1a, 1d	1a	7c	1a	1a	1a, 1d	1a	1a, 1d	1a	1d	1d	1.a.4 1.d.4
	Hatchery Fraction		1a, 1b, 1d, 6b	1a, 1b, 6b		6b	1a, 1b, 1d, 6b	1a, 1b, 6b	6b	1a	1a	1a, 1b, 1d, 6b	1a, 1b, 6b	1a, 1b, 1d, 6b	1a, 1b, 6b	1d	1d	1.a.5 1.d.5
	Harvest Abundance in Tributary		1a, 1d, 5b	1a, 5b		1d, 5b	1a, 1d, 5b	1a, 5b	5b	1a, 5b	1a, 5b	1a, 1d, 5b	1a, 5b	1a, 1d, 5b	1a, 5b	1d	1d	5.b.1 5.b.2
	Index of Juvenile Abundance (Density)	7b			7b													7.b.1
	Juvenile Emigrant Abundance	1e	1d, 7b		1e, 7b	1d	1d, 7b		1d, 7b	7b		1d, 7b		1d, 7b		1d	1d	1.d.14
	Hatchery Production Abundance			1a, 6a				1a, 6a			1a. 6a		1a, 6a		1a, 6a			6.a.1
	Smolt Equivalents	1e	1d	1a	1e	1d	1d	1a	1d	1a	1a	1d	1a	1d	1a	1d	1d	1.d.15
	Run Prediction		5a, 6b	5a, 6b		5a	5a, 6b	5a, 6b	5a	5a, 6b	5a, 6b	5a, 6b	5a, 6b	5a, 6b	5a, 6b			5.a.1
Survival - Productivity	Smolt-to-Adult Return Rate	1e	1e	1e, 6a, 6b	1e			1e, 6a, 6b			1e, 6a, 6b		1e, 6a, 6b		1e, 6a, 6b			1.e.3 1.e.4
	Progeny-per- Parent Ratio		1a, 1d, 7b	1a		1d, 7b	1a, 1d, 7b	1a,	1d, 7b	1a, 7b	1a	1a, 1d, 7b	1a	1a, 1d, 7b	1a	1d	1d	1.a.10 1.d.1
	Recruit/spawner (Smolt Equivalents per Redd or female)		1a, 1d	1a		1d	1a, 1d	1a	1d			1a, 1d	1a	1a, 1d	1a	1d	1d	1.d.16
	Pre-spawn Mortality (female 0-25%)		1a, 1d	1a		1d	1a, 1d	1a	1d	1a	1a	1a, 1d	1a	1a, 1d	1a	1d	1d	1.a.8 1.d.6
	Harvest Rate (Ocean and Columbia River)																	
	Juvenile Survival to Lower Granite Dam		1d, 1e	1d, 1e, 6a	1e	1d	1d, 1e	1d, 1e, 6a	1d		6a	1d, 1e	1d, 1e, 6a	1d, 1e	1d, 1e, 6a	1d	1d	1.d.15
	Juvenile Survival to all Mainstem Dams	7e		7e	7e													1.d.15
	In-hatchery Life Stage Survival			6a				6a			6a		6a		6a			6.a.1
	Post-release Survival			1e														1.e.1
	Relative Reproductive Success (Parentage)		1b				1b					1b		1b				1.b.1

Distribution	Adult Spawner Spatial Distribution	7d	1c, 7d	1c		7d	1c, 7d	1c	7d	1c, 7d	1c	1c, 7d	1c	1c, 7d	1c			1.c.1
	Stray Rate		4c	4c		4a	4c	4c	4a	4c	4c	4c	4c	4c	4c			1.a.2
	Juvenile Rearing Distribution	7b	7b		7b		7b			7b		7b		7b				7.b.2
	Disease Frequency		6c	6c		6c	6c	6c	6c	6c	6c	6c	6c	6c	6c			6.c.1 6.c.2
Genetic	Genetic Diversity		2c, 3a	2c, 3a		2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a			2.c.3 3.a.2
	Reproductive Success (Nb/N)		2c, 3a	2c, 3a		2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a			2.c.4 3.a.2
	Effective Population Size (Ne)		2c, 3a	2c, 3a		2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a	2c, 3a			2.c.4 3.a.2
Life History	Age Class Structure		1a, 1b, 1d, 6b	1a, 1b, 6b		1d	1a, 1b, 1d, 6b	1a, 1b, 6b	1d	1a	1a	1a, 1b, 1d, 6b	1a, 1b, 6b	1a, 1b, 1d, 6b	1a, 1b, 6b	1d	1d	1.a.6
	Age–at–Return		1a, 1d, 2a, 3b	1a, 2a, 3b		2a	1a, 1d, 2a, 3b	1a, 2a, 3b	1d, 2a	1a, 6b	1a, 6a, 6b	1a, 1d, 2a, 3b	1a, 2a, 3b	1a, 1d, 2a, 3b	1a, 2a, 3b	1d	1d	1.a.6
	Age–at-Emigration		2b, 3c	3c			2b, 3c	3c	2b			2b, 3c	3c	2b, 3c	3c			2.b.1 1.d.14
	Size-at-Return		2a, 3b	3b		2a	2a, 3b	3b	2a			2a, 3b	3b	2a, 3b	3b			2.a.2 1.a.2
	Size-at-Emigration		2b, 3c	3c			2b, 3c	3c	2b			2b, 3c	3c	2b, 3c	3c			2.b.2
	Condition of Juveniles at Emigration		2b, 3c	3c			2b, 3c	3c	2b			2b, 3c	3c	2b, 3c	3c			2.b.2
	Adult Spawner Sex Ratio		1a, 1b, 1d, 2a, 3b	1a, 1b, 3b		1d, 2a	1a, 1b, 1d, 2a, 3b	1a, 1b, 3b	1d, 2a			1a, 1b, 1d, 2a, 3b	1a, 1b, 3b	1a, 1b, 1d, 2a, 3b	1a, 1b, 3b			1.a.7
	Fecundity by Age		1b, 3b	1b, 3b			1b, 3b	1b, 3b				1b, 3b	1b, 3b	1b, 3b	1b, 3b			3.b.2
	Adult Run-timing		2a, 3b	3b, 6a		2a	2a, 3b	3b, 6a	2a		6a	2a, 3b	2a, 3b	2a, 3b	2a, 3b			2.a.4
	Spawn-timing		1b	1b			1b	1b				1b	1b	1b	1b			3.b.3
	Juvenile Emigration Timing		2b, 3c	3c			2b, 3c	3c	2b, 3c			2b, 3c	3c	2b, 3c	3c			1.d.14 2.b.2
	Mainstem Arrival Timing (Lower Granite)		2b, 3c	3c, 6a			2b, 3c	3c, 6a	2b, 3c		6a	2b, 3c	3c, 6a	2b, 3c	3c, 6a			2.b.3
Habitat	Physical Habitat	7a			7a													7.a.1
	Stream Network																	
	Passage Barriers/Diversions																	
	Instream Flow	7a	7a	7a	7a		7a	7a			7a	7a	7a	7a	7a			7.a.3
	Water Temperature	7a	7a	7a	7a		7a	7a			7a	7a	7a	7a	7a			7.a.2
	Chemical Water Quality																	
	Macroinvertebrate Assemblage																	
	Fish and Amphibian Assemblage																	

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

ACKNOWLEDGMENTS

Many have contributed to this text and its development. The authors relied on numerous contemporary documents to develop a monitoring and evaluation plan that we trust will result in information with broad applicability. We are thankful specifically to the following scientists and managers who provided their suggestions, valuable insight and expertise regarding the Chinook salmon resources of northeast Oregon: Steve Boe, Peter Cleary, Craig Contour, Tim Hoffnagle, Saang-Yoon Hyun, Brain Jonasson, Patrick Keniry, Bill Knox, Jerry Lockhart, Paul Moran, Joseph Oatman, Sam Onjukka, Jim Ruzycki, Rishi Sharma, Brad Smith, Erik Tinus, and Jason Vogel.

We also benefited immensely from numerous iterative reviews in developing the plan. Members of the Independent Scientific Review Panel, Independent Scientific Advisory Board, and Collaborative Systemwide Monitoring and Evaluation Project have all reviewed and/or commented on our plan. The plan continues to draw upon federal, state, tribal, academic and other independent sources for monitoring and evaluation council and guidance. It is our desire that the NEOH M&E Plan not become a static document, but continues to evolve as new and advantageous methods for assessing supplementation become available. Therefore, we look forward to continued interaction with the region's monitoring and evaluation experts.

Finally, we extend our gratitude to the Bonneville Power Administration for their financial support during the development of this monitoring and evaluation plan and for continual funding as we transition from planning to implementation.

INTRODUCTION

PURPOSE AND SCOPE

This document describes a status monitoring and management action evaluation plan for Imnaha and Grande Ronde subbasin spring/summer Chinook salmon (*Oncorhynchus tshawytcsha*). It was developed to guide evaluation of the Northeast Oregon Hatchery (NEOH) program, an artificial production program. The monitoring and evaluation (M&E) activities corporately form an information-gathering strategy to assess NEOH effectiveness and impacts to the natural populations that will enable accountability for performance and direction. As have many entities, we have adopted the definition of supplementation developed by the Regional Assessment of Supplementation Project (RASP, 1992):

> *"Supplementation is the attempt to use artificial propagation to maintain or increase natural production while maintaining the long term fitness of the target population, and while keeping the ecological and genetic impacts on non-target populations within specific biological limits"*

Many of the monitoring and evaluation activities described in this plan are in place as part of the Lower Snake River Compensation Plan (LSRCP) and the Columbia Basin Fish and Wildlife Program. A diverse monitoring program was implemented with the Lower Snake River Compensation Plan for natural and hatchery production assessment in northeast Oregon. We acknowledge and describe these ongoing activities as components of this plan. Given the complexity of Chinook salmon enhancement endeavors in northeast Oregon, this document functions as a framework to organize, direct and coordinate activities, establish precision targets, and prioritize ongoing and new activities.

Monitoring and evaluation of the NEOH program will provide information to guide adaptive management for each of the major categories incorporated in the RASP definition at multiple life stages for hatchery and natural-origin Chinook salmon. Supplementation effectiveness evaluated under this M&E program includes effects on the abundance, distribution, productivity and diversity of Chinook salmon populations in the Imnaha and Grande Ronde subbasins. In addition to measuring program-related benefits, the M&E program will provide information on life history and genetic characteristics of the natural population and the performance of adult and juvenile hatchery-origin fish relative to natural-origin fish standards. This plan is intended to give early warning of adverse effects caused by the program and to track biological and abiotic trends that may affect program success.

This plan describes the need and quantification requirements for M&E activities to provide program guidance. We start with an overview of the NEOH program and the management goals and objectives. Associated with each objective are a suite of anticipated outcomes (assumptions) that serve as a foundation to focus monitoring and evaluation objectives. The approach to monitoring and evaluation follows with the M&E goal and M&E objectives and a description of the overall experimental design. Specific monitoring and evaluation methodology including statistical techniques is then detailed for each M&E objective.

STUDY AREA

The Imnaha River subbasin is located in northeastern Oregon and encompasses an area approximately 1,577 km^2 (*Figure 1*). A comprehensive description of the Imnaha River subbasin is found in the Imnaha Subbasin Summary (Bryson et al. 2001). The mainstem Imnaha River flows northerly for 128 km from its headwaters in the Eagle Cap Wilderness Area (elevation 3,048 m), to its confluence with the Snake River at river kilometer (Rkm) 309 (elevation 288 m). The Imnaha River subbasin is fairly linear with only one major tributary, Big Sheep Creek. The Imnaha River is part of the National Wild and Scenic Rivers System with sections classified as wild, recreational, and scenic.

The Grande Ronde River subbasin encompasses an area of 6,356 km^2 in the northeast corner of Oregon and a small portion of southeast Washington. Comprehensive description of the Grande Ronde River subbasin can be found in the Grande Ronde Subbasin Summary (Nowak et al. 2001). The mainstem Grande Ronde River extends 341km from its headwaters in the Elkhorn Mountains (elevation 2,347 m) and the Wallowa Mountains (elevation 3,048 m) to its confluence with the Snake River in Washington at Rkm 272 (elevation 250 m). The subbasin is characterized by two major river valleys, the Wallowa and Grande Ronde, surrounded by rugged mountain ranges. Major tributaries include: Joseph Creek, Wenaha River, Lookingglass Creek, Wallowa River, Minam River, Lostine River, Upper Grande Ronde River, and Catherine Creek (*Figure 1*). The Wenaha and Minam rivers are designated as wild under the National Wild and Scenic Rivers system.

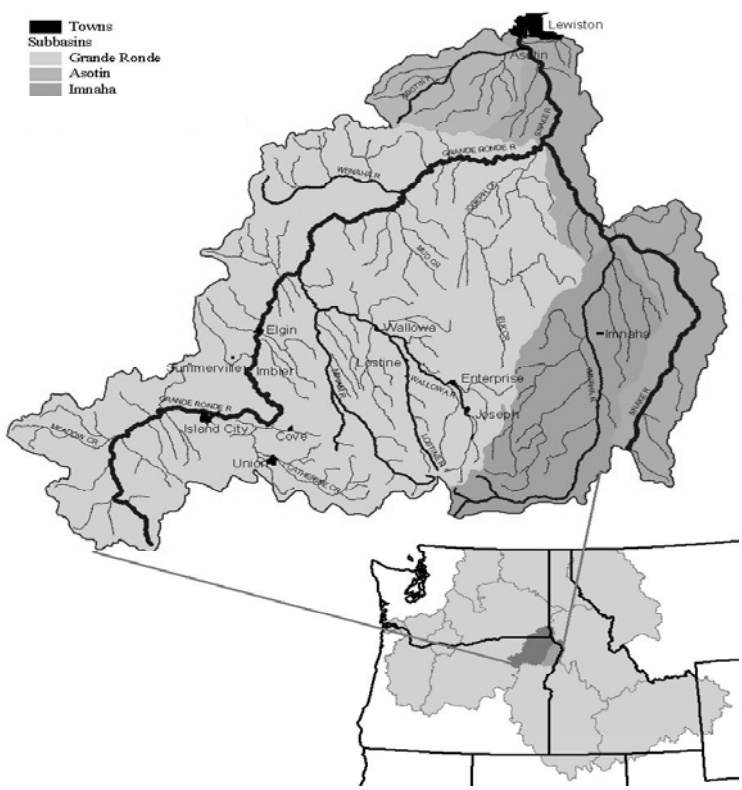


Figure 1. Imnaha and Grande Ronde subbasins.

POPULATION STATUS

Understanding and describing the current and historical status of high priority populations is fundamental to proper fisheries management. Imnaha and Grande Ronde River subbasin spring Chinook salmon were listed as threatened under the Endangered Species Act (ESA) in 1992. The following represents a summary of the Chinook salmon populations found in both subbasins according to the Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units (VSP) format (McElhany et al. 2000). Presentation of existing data is currently underway and will be provided as a living supplement to this plan within the Step 3 submittal (see also section 8a of this report).

Imnaha Subbasin

Historically, the Imnaha subbasin supported one of the largest runs of spring/summer Chinook salmon in northeast Oregon (Wallowa County and Nez Perce Tribe 1993). It remains an important contributor to Snake River salmon populations. Thus, this population has major cultural and social significance for tribal and non-tribal people of northeast Oregon.

Abundance

Prior to the construction of the four lower Snake River dams, an estimated 6,700 adult wild spring/summer Chinook salmon escaped to the subbasin annually (USACE 1975). Since dam construction, some return years have seen as few as 150 natural origin adults (ODFW 1998). In the past four years (2000-2003), returns have increased to a 2,364 – 6,543 individuals (Keniry 2003). This escapement total represents both natural and hatchery origin adults.

Survival

Progeny-to-parent ratios for natural spawning spring/summer Chinook salmon have been well below replacement for most brood years since 1983 and as low as 0.2 (Carmichael et al.1998). Natural smolt survival estimates to Lower Granite Dam have ranged from 76.2% in 1994 to 90.9% in 1995. Survival estimates modeled from the mouth of the Imnaha River to Lower Granite Dam for hatchery smolts have ranged from 67.1% (± 10.2%) in 1994 to 80.4% in 1997 (Cleary et al. 2000 and 2003).

Distribution

Spring/summer Chinook salmon are endemic to the Imnaha subbasin. Spawning was distributed throughout the mainstem Imnaha River to the confluence of the North and South Forks and the Big Sheep Creek drainage (Thompson and Haas 1960, Witty 1988). Spawning has been observed in smaller tributaries including: Lightning, Lick, and Little Sheep creeks are recorded (Ashe et al. 2000). Current spawning distribution in the Imnaha subbasin is much reduced, with the majority of spawning occurring from Blue Hole downstream to Crazyman Creek (*Figure 2*), with small numbers in Big Sheep Creek.

Life History

Adult Migration - Based on information from radio tagged adult Chinook salmon, fish that entered the Imnaha River passed Ice Harbor Dam from late April - mid July in 1991 (Bjornn et al.1992) and from late April - early July in 1992 (Bjornn et al. 1993). Migration timing of these fish fall into both the spring and summer Chinook salmon classifications. Historical records and observations of long-time Imnaha residents indicate some spawning began as early as late July in the lower portions of the subbasin (Mundy and Witty 1998). Currently most adult spring Chinook salmon begin entering the Imnaha River in late-April, with peak entry in mid-to-late June (Ashe et al. 2000).

Spawning - Spawn timing is correlated with water temperature (Lister et al. 1981). Chinook salmon spawn in progressively lower reaches as temperatures drop to the preferred range. In the Imnaha River, spawning occurs later in the lower reaches than in the upper reaches where temperatures are cooler earlier in the season. The distribution and use of spawning habitat reflects this correlation with early arriving adults generally migrating high in the subbasin and as the season progresses, the adult distribution moves downstream (Mundy and Witty 1998). Peak spawning usually occurs from late August to early September (Ashe et al. 2000). In the past, peak spawning in the Imnaha occurred prior to August 24, based on spawning ground surveys conducted by the Oregon Fish Commission (Thompson and Haas 1960).

Juvenile Freshwater Rearing - Spawning in early August would be expected to produce emergent fry in early November, approximately 100 days after incubation. Yet, eggs deposited in the gravel several weeks later would have a 4 month delay in fry emergence in order to accumulate sufficient temperature units for incubation (Mundy and Witty 1998). The wide range in timing of fry emergence relative to spawn timing may indicate that this is a critical survival adaptation for Imnaha spring Chinook salmon in response to environmental conditions (Mundy and Witty 1998). Juvenile Chinook salmon use portions of the mainstem and several of the lower tributaries (Cow, Lightning, Horse, Big Sheep and Lick creeks; Figure 4) for rearing. Mundy and Witty (1998) reported that juvenile Chinook salmon may also use the lower reaches of Skookum, Gumboot, Mahogany, Crazyman, Summit, Grouse, and Freezeout creeks. Prior to their emigration, parr and pre-smolts will distribute throughout Big Sheep Creek and the upper, middle and lower Imnaha, and Snake River from September throughout the winter and into spring (Ashe et al. 2000).

Juvenile Emigration - Naturally produced smolts typically maintain a protracted emigration from the system, and have been documented passing the Cow Creek fish trap (rkm 7) from the middle of February to the middle of July (Ashe et al. 2000). This is in contrast to hatchery smolts acclimated and released from the Gumboot facility. Cleary (1998) observed hatchery smolts at the Cow Creek smolt trap on April 5 (same day that fish were force released from the acclimation facility) with the last hatchery fish observed on May 17. Almost all of the hatchery smolts (99%) were recorded from April 5 to April 19. Changes in smolt release strategies in 1999 from forced release to volitional releases at the Gumboot facility appears to have extended the migration timing for hatchery smolts. Hatchery smolts were observed from early March to early June with peak migration occurring from mid March to the middle of May (Ashe et al. 2000).

Several studies describe migration timing for natural Imnaha smolts to lower mainstem Snake River dams. From 1988 to 1995 the National Marine Fisheries Service PIT-tagged natural juvenile Chinook from several Snake River populations in August and September (Achord et al. 1991). The Imnaha population is sampled each year and detections are recorded at Lower Granite, Little Goose, and McNary Dams. The median passage time for Imnaha juveniles was mid-April to early May for the years of the study. The Nez Perce Tribe has PIT tagged natural Imnaha juveniles since 1994 for interrogation at Lower Granite, Little Goose, Lower

Monumental, and McNary Dams (Ashe et al.1995, Blenden et al. 1996, Cleary et al. 2003). Arrival timing ranges from early April to early August.

Genetics

The Imnaha River spring Chinook salmon appear to be genetically distinct from neighboring populations, and this was recognized prior to hatchery intervention (Carmichael et al. 1998b, Mundy and Witty 1998). In 1989 and 1990, sub-yearling Chinook were sampled from various Snake River Subbasin populations, including the Imnaha River. The sampled fish were electrophorectically analyzed by NMFS for enzymatic frequencies associated with 39 loci (Waples et al. 1993). The Imnaha grouped with natural populations from the Grande Ronde Subbasin (Lostine River, Catherine Creek, and Minam River populations) before it grouped with natural populations from the Salmon River Subbasin (Upper Salmon and Secesh Rivers and Johnson, Marsh and Valley creeks) (Neeley et al. 1993). Imnaha River hatchery-produced fish do not differ genetically from naturally produced fish (Carmichael and Messmer 1995, Neeley et al. 1993). However, the Imnaha differed significantly from all Grande Ronde and Salmon River populations evaluated (Waples et al. 1993). More recent analysis of population structure by the Interior Columbia Basin Technical Recovery Team reaffirmed hatchery and wild collections from the mainstem Imnaha River were genetically indistinguishable within the cluster containing most of the Grande Ronde collections and were distinct from all but the most closely aligned Lostine River samples. The genetic distinction, large distance from other populations, and life-history differences support its status as an independent population (IC-TRT 2003).

The uniqueness of the Imnaha stock led to a decision to use only endemic fish for the hatchery program and to use some natural fish for hatchery broodstock each year (Ashe et al. 2000). Beginning with the 1982 brood year, naturally produced returning adults were trapped for broodstock at the Gumboot weir facility located at RM 47. Broodstock in subsequent years have been composed of hatchery and natural-origin fish.

Habitat

Three-quarters of the subbasin is under public ownership and most lies within the boundaries of the Hells Canyon National Recreational Area. The area above Indian Crossing is within the boundaries of the Eagle Cap Wilderness Area. Moderate levels of logging, ranching and road building have affected the subbasin, but habitat conditions have shown little change since the mid-1950s (Carmichael and Boyce 1986). Salmonid habitat is rated as good or excellent (Ashe et al. 2000).

Harvest

Mainstem harvest of Imnaha Chinook salmon is generally low in recent years. Ocean harvest is also low. Sport harvest in the Imnaha River subbasin was closed after 1978. A sport and tribal spring Chinook salmon fisheries occurred in the Imnaha River subbasin during 2001, 2002 and 2003 in response to increased adult returns. In 2003, the estimated combined tribal and recreational fisheries harvest was 315 hatchery fish and an incidental mortality of 27 wild fish (Smith 2003; Oatman 2003).

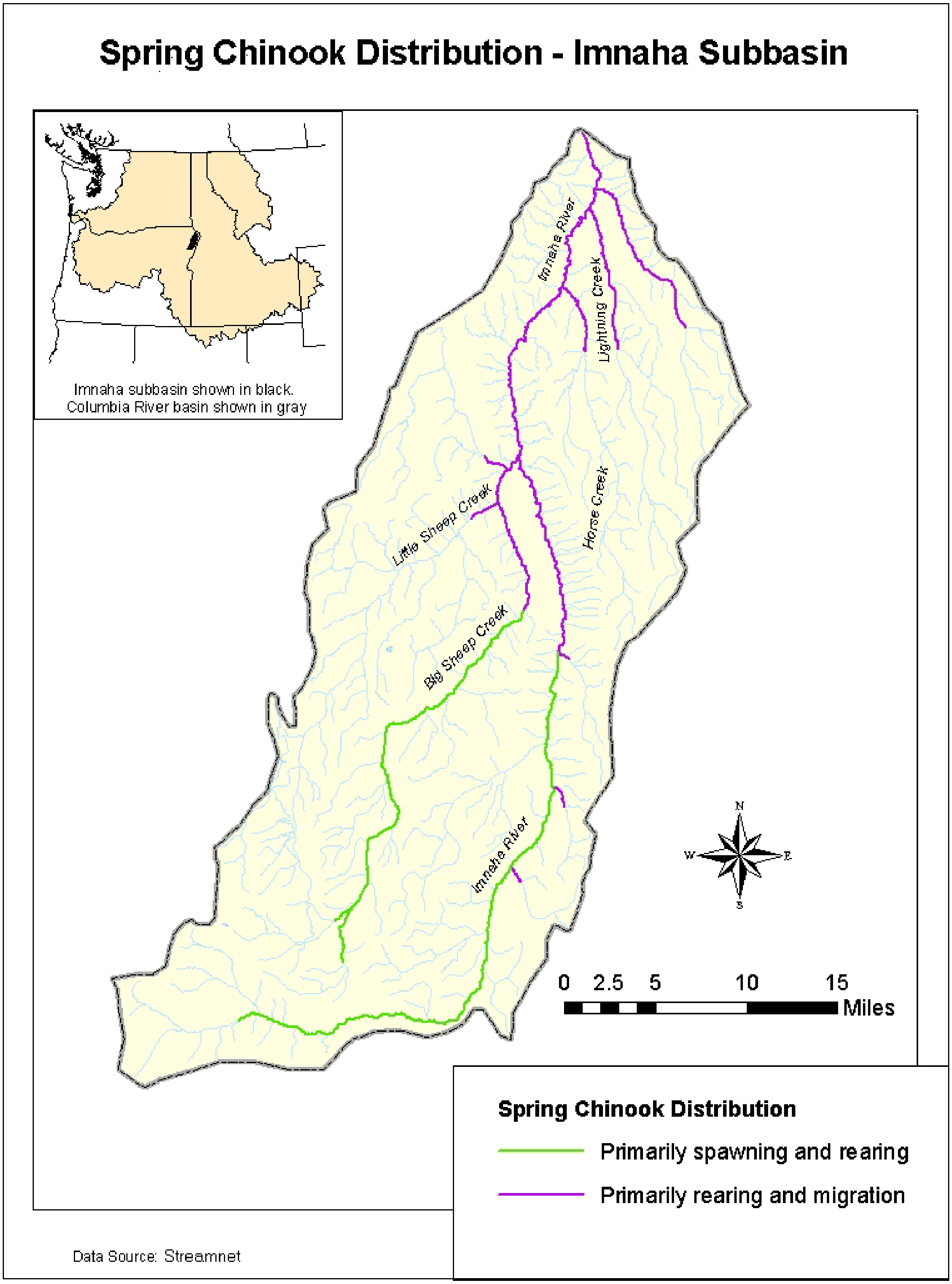


Figure 2. Spawning and rearing distribution of spring/summer Chinook in the Imnaha Subbasin.

Grande Ronde Subbasin

Historically, the Grande Ronde River subbasin maintained rich and diverse fish populations that supported fisheries that were important to Native American and European cultures and economies (James 1984, Ashe et al. 2000). These fisheries included Chinook salmon that reflected healthy, vigorous populations throughout the subbasin.

Abundance

Spawning ground surveys have been conducted throughout the Grande Ronde subbasin since the late 1940's to assess trends in abundance of spawning fish. These surveys document declining trends in escapement. Spring Chinook spawning escapement in the subbasin was estimated at 12,200 fish in 1957 (USACE 1975). Redd counts indicate that large runs of spring Chinook returned until the early 1970's. Presently the most productive streams in the subbasin are the Wenaha, Lostine and Minam Rivers, and Catherine Creek (Ashe et al. 2000). But these tributaries are also showing declining trends. However, like the Imnaha River, some Grande Ronde populations have had relatively high returns of natural and hatchery fish in the past 3 years (Keniry 2001, 2002, 2003).

Survival

Progeny-to-parent ratios for Grande Ronde River subbasin Chinook salmon have been below replacement for the past eight completed brood years (Carmichael et al. 1998). Estimates for natural-origin smolt survival to Lower Granite Dam has ranged from 50.5 – 74.4% in the Lostine River, 31.8 – 45.2% in Catherine Creek, and 37.9 –56.0% in the Upper Grande Ronde during the past five out-migration years (ODFW unpublished data). Estimates for hatchery-origin smolt survival to Lower Granite Dam has ranged from 72.3% - 56.0% for the Lostine River, 35.0-54.0% for Catherine Creek, and 38.1 to 50.8% for Upper Grande Ronde production during the past five out-migration years (Harbeck 2003 and ODFW unpublished data).

Distribution

Spring Chinook salmon are indigenous to the Grande Ronde River subbasin and were distributed throughout the river system. Twenty-one tributaries supported spring Chinook runs, contributing to large documented runs in the subbasin. In the Wallowa system spawning populations were present in Prairie Creek, Spring Creek, Hurricane Creek, Bear Creek, Minam River and Little Minam River, Lostine River, Wallowa River and Deer Creek (Thompson and Haas 1960). Spawning populations in the Grande Ronde River were found in Sheep Creek, Catherine Creek, Indian Creek, Lookingglass Creek, and in the mainstem Grande Ronde between the guard station and the East Fork. The Wenaha River included populations in both the North and South Forks (Thompson and Haas 1960). Neeley et al. (1994) believe that native spring Chinook populations are now extirpated in Spring, Prairie, Deer, Indian and Lookingglass Creeks.

Life History Traits

Adult Migration - Grande Ronde spring Chinook typically enter the Columbia River from March through June (Neeley et al. 1994) and pass through the lower Snake River from April through mid-July (Thompson et al. 1958; Bjornn et al. 1992). In the past adult Chinook returns to the Grande Ronde subbasin were continuous with the first fish arriving in early May, with peak returns in June and July depending on the water year, and the last fish arriving in October.

Spawning - Spawning usually occurs in August and September. Adult spring Chinook salmon return to spawn at ages 3 to 6, but the dominant age class is age 4. Known spawning and rearing areas within the subbasin are illustrated in Figure 3.

Juvenile Freshwater Rearing - Incubation of eggs deposited in the gravel occurs from the time of deposition in August and September until hatching which is dependant on the accumulation of temperatures units. Fry are thought to emerge beginning in March and continuing through early June (Hurato 1993). Tributaries in the Grande Ronde and Wallowa valleys exhibit highly variable habitats for rearing of parr and pre-smolts. It is suspected that fry and parr drift downstream from spawning areas and rear throughout all reaches of the stream (Jonasson et al.1997). Researchers also believe the late-summer/fall parr drift downstream into the lower reaches of the Wallowa and Grande Ronde rivers, and even into the Snake River by December or January.

Juvenile Emigration - Most spring Chinook salmon juveniles rear in their natal tributaries of the Grande Ronde for one year before migrating to the ocean as smolts from March through May. Some juveniles, however, emigrate from their natal streams during their first year and overwinter lower in the subbasin (Jonasson et al. (1997). Studies of juvenile Chinook PIT tagged in the Grande Ronde River and later detected at Lower Granite Dam indicate that Grande Ronde River smolts out-migrate at approximately the same time as other Salmon River stocks, but later than the Imnaha stock (Mathews et al.1990; Achord et al. 1992).

Genetics

An Independent Scientific Panel (Currens et al. 1996) of geneticists reviewed and analyzed genetic data collected from Grande Ronde Subbasin spring Chinook salmon. Based on this analysis, the Panel determined that despite hatchery releases in the subbasin of non-native stock (Rapid River and Carson stock), a substantial component of the native spring Chinook populations still exists. The Panel also found the Lostine population was the most distinctive of the naturally spawning populations in the Grande Ronde (Currens et al. 1996). Recent analysis of population structure by the Interior Columbia Basin Technical Recovery Team reaffirmed Wenaha River, Lostine River (including the Wallowa River, Bear Creek, and Hurricane Creek), Minam River, Catherine Creek (including Indian Creek), and the Upper Grande Ronde River (including Sheep Creek) are genetically and geographically distinct and should be considered independent populations (TRT 2003).

Habitat

Declines in abundance of Grande Ronde River spring Chinook salmon populations are attributed in part to mainstem habitat alterations and passage problems at Columbia and Snake River dams (ODFW et al. 1990). Grande Ronde River anadromous fish must pass a total of 8 dams during up- and downstream migrations. Within the Grande Ronde River subbasin, riparian and in stream habitat degradation affects spring Chinook salmon production potential. As in other subbasins, livestock overgrazing, logging activity, mining, channelization and irrigation water withdrawls limit the quantity and quality of salmon habitat in the Grande Ronde.

Harvest

Sport harvest in the Grande Ronde Subbasin was closed 1974 in Oregon and 1977 in Washington. A short term sport and tribal spring Chinook salmon fishery occurred on Lookingglass Creek in 2001 and 2002, targeting Lookingglass Hatchery Rapid River stock.

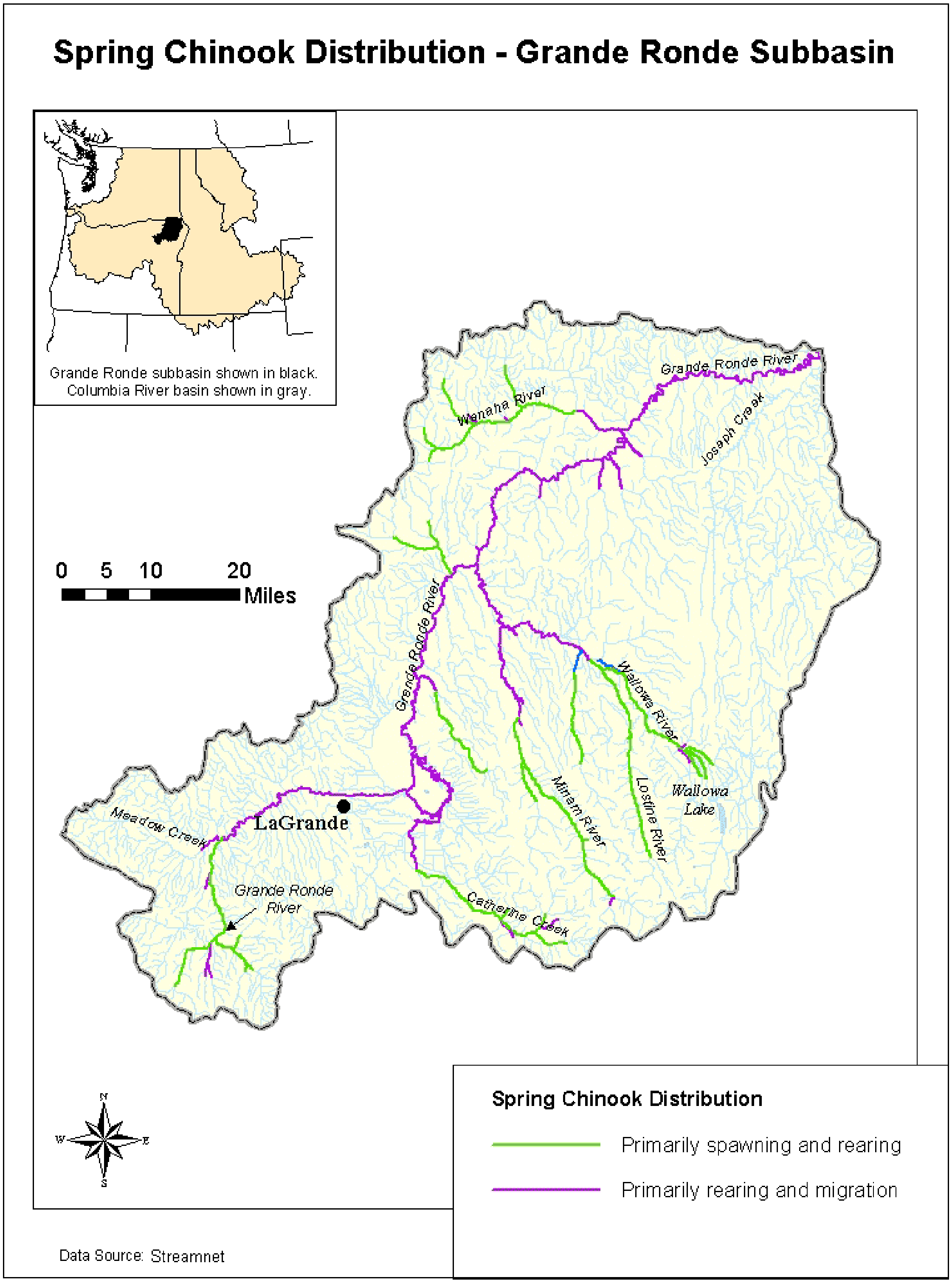


Figure 3. Spawning and rearing distribution of spring/summer Chinook in the Grande Ronde Subbasin.

GLOSSARY OF DEFINITIONS

Aggregate - a spawning population within a defined geographic location at a given time.

Allozyme – a form (amino acid sequence) of an enzyme produced by a specific allele at a given locus.

Captive Broodstock - a stock consisting of fish that are reared in captivity for their entire lives for the purpose of obtaining gametes.

Carrying Capacity – the maximum number of a species that can be supported indefinitely by a defined habitat area.

Cohort – a group of individuals from the same birth year.

Coded Wire Tag (CWT) – an internal tag made of a small piece of magnetized stainless steel wire that is coded by a system of notches for individual or batch identification.

Control Stream - see reference stream.

Experimental Unit - any group of organisms that receives a unique experimental treatment.

Fecundity – the reproductive capacity of an individual usually measured as the number of eggs produced by a female in a specified period of time.

Fishery – exploitation or catch specific to human removal of fish from the natural environment or population.

Hatchery Fish - progeny of parents which are spawned artificially and the resulting offspring are then held in an artificial environment for some segment of their incubation or rearing.

Local Hatchery Stock - a hatchery stock founded from the natural population that inhabits the location of release.

Natural Fish - progeny of parents which spawned voluntarily in the natural environment.

Natural origin hatchery stock - A hatchery stock consisting of fish whose parents were naturally produced.

Non-local hatchery stock - A hatchery stock founded using fish from a different population than the one into which the stock is released.

Non-target Population – includes all other aggregates or populations regardless of origin or location not intended to be influenced by management actions directed towards the target population.

Passive Integrated Transponder (PIT) - a small transmitter injected into an animal that transmits an identification signal only when it is stimulated by an external electronic query.

Performance Measure – a biological indicator that quantitatively describes structural or functional attributes of interest. They are sensitive to natural or human alteration and are useful in monitoring and judging ecological performances.

Population – a group of fish that belong to the same species and freely interbreed that are relatively reproductively isolated from other breeding groups.

Production Strategy – an approach or technique to culture fish for a specific purpose.

Production Group – hatchery fish which were spawned, incubated, reared and release for the primary purpose of increasing natural production in a specific target population.

Progeny – biological offspring

Reference Stream – population or area of study excluded from direct management actions used to characterize status quo conditions.

Relative Fitness - breeding success and/or survival of one group measured as a proportion of another group.

Run Reconstruction – partitioning of annual adult escapement by age, sex, origin.

Smolt Equivalent – an estimated number of smolts from a population that successfully emigrate (reach) from a specified area (i.e. tributary mouth or Lower Granite Dam).

Status – characterization of a population's abundance, growth rate, spatial structure, and diversity.

Subbasin – the surface area of a watershed drained by a tributary to a larger stream that is bounded by ridges or other hydrologic divides and is located within the larger watershed drained by the larger stream.

Supplementation – 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 with specified biological limits.

Target Population or Treatment Stream – the intended aggregate of hatchery, natural or wild fish influenced by management actions such as supplementation and about which inferences will be made based on those actions.

Visible Implant Elastomere (VIE) Tag – a visible implant tag made of a biocompatible polymer injected into transparent tissue.

Wild Fish – natural fish whose ancestry has not been supplemented or influenced with hatchery fish.

OVERVIEW OF THE NORTHEAST OREGON HATCHERY PROGRAM

The Northeast Oregon Hatchery program represents an effort by co-managers to improve existing artificial propagation management actions supporting mitigation, conservation and recovery of spring/summer Chinook salmon in northeast Oregon. NEOH proponents have addressed the need to renovate/modify existing hatchery facilities in the Imnaha and Grande Ronde subbasins. NEOH proponents also recommend the construction of new facilities for an integrated fish management program. These modified and new facilities will make it possible to improve the effectiveness of the currently permitted (Endangered Species Act -National Ocean and Atmospheric Administration) and approved production program for spring/summer Chinook salmon in the Imnaha and Grande Ronde subbasins.

NORTHEAST OREGON HATCHERY MANAGEMENT GOALS AND OBJECTIVES

The beginning of an effective management endeavor such as the NEOH program is a management framework that encompasses the population in question, its ecosystem, and society's values (Lichatowich et al. 1996; Moring 1993). That framework is what links management actions to societal values and expectations. It is also the structure that keeps the actions relevant to the program vision (Bisbal 2001). Current vision for the Grande Ronde and Imnaha subbasins is stated in their respective subbasin summaries (Bryson et al 2001; Novak et al. 2001). The most familiar expression of a vision is in terms of a goal statement. The common long-term goal of co-managers for the Imnaha and Grande Ronde subbasins is *to restore and/or maintain the health and function of the ecosystem to ensure continued viability of important populations.*

A series of short, mid, and long-term goals are also identified in the Northeast Oregon Hatchery Spring Chinook Salmon Master Plan (Ashe et al. 2000). These goals incorporate existing LSRCP mitigation goals. These goals focus on (1) preservation/conservation actions to avoid extinction, (2) restoration (recovery) to build population abundances above critical threshold levels, and (3) mitigation (compensation) to support harvest and self-sustaining populations. Each of these goals have related objectives that detail some level of annual escapement and state the need to maintain genetic attributes and life history characteristics of the naturally spawning Chinook salmon populations that support:

- Protection, mitigation, and enhancement of Columbia River basin anadromous fish resources;
- Long-term harvest opportunities for tribal and non-tribal anglers;
- Long-term fitness and genetic integrity of targeted fish populations; and
- Limiting ecological and genetic impacts to non-target populations within acceptable limits.

Management Objectives
After establishing management goals, managers developed objectives that define progress towards achievement of those goals and that would provide a measurable definition of attainment (Krueger and Decker 1993). The following objectives were formulated to meet the goals stated above and to address management needs. These management objectives are structured to address the RASP definition of supplementation (RASP 1992).

Management Objective 1: Maintain and enhance natural production in supplemented spring Chinook salmon populations in the Imnaha and Grande Ronde river subbasins.

Management Objective 2: Maintain life history characteristics and genetic diversity in supplemented and unsupplemented spring Chinook salmon populations in the Imnaha and Grande Ronde river subbasins.

Management Objective 3: Operate the hatchery program so that life history characteristics and genetic diversity of hatchery fish mimic natural fish.

Management Objective 4: Keep impacts of hatchery program on non-target spring Chinook salmon populations within acceptable limits.

Management Objective 5: Restore and maintain treaty-reserved tribal harvest and recreational fisheries.

Management Objective 6: Operate the hatchery programs to achieve optimal production effectiveness while meeting priority management objectives for natural production enhancement, diversity, harvest, impacts to non-target populations.

Management Objective 7: Understand the current status and trends of spring Chinook salmon natural populations and their habitats in the Imnaha and Grande Ronde river subbasins.

Management Objective 8: Coordinate management action and monitoring and evaluation activities and communicate program findings to resource managers.

Management Assumptions
Management assumptions that can be tested by quantifiable means were structured from management questions (Appendix A- modified from Hesse and Harbeck 2000). The management questions were developed through co-management meetings, recommendations and review of monitoring and evaluation literature. To achieve success, the following assumptions must be met for each management objective:

Management Objective 1: Maintain and enhance natural production in supplemented spring Chinook salmon populations in the Imnaha and Grande Ronde river subbasins.

A. Progeny-to-parent ratios for hatchery-produced fish significantly exceeds those of natural-origin fish.
B. Natural reproductive success of hatchery-origin fish must be similar to that of natural-origin fish.

C. Spatial distribution of hatchery-origin spawners in nature is similar to that of natural-origin fish.
D. Productivity of supplemented populations is similar to productivity of populations if they had not been supplemented.
E. Life stage-specific survival is similar between hatchery and natural-origin population components.

Management Objective 2: Maintain life history characteristics and genetic diversity in supplemented and unsupplemented spring Chinook salmon populations in the Imnaha and Grande Ronde river subbasins.

A. Adult life history characteristics in supplemented populations remains similar to pre-supplementation population characteristics.
B. Juvenile life history characteristics in supplemented populations remains similar to pre-supplemented population characteristics.
C. Genetic characteristics of the supplemented population remain similar (or improved) to the unsupplemented populations.

Management Objective 3: Operate the hatchery program so that life history characteristics and genetic diversity of hatchery fish mimic natural fish.

A. Genetic characteristics of hatchery-origin fish are no different than natural-origin fish.
B. Life history characteristics of hatchery-origin adult fish are similar to natural-origin fish.
C. Juvenile emigration timing and survival differences between hatchery and natural-origin fish must be minimal.

Management Objective 4: Keep impacts of hatchery program on non-target spring Chinook salmon populations within acceptable limits.

A. Hatchery strays produced from the northeast Oregon Hatchery Program do not comprise more than 10% of the naturally spawning fish in the Wenaha and Minam watersheds.
B. Hatchery strays in the Minam and Wenaha rivers are predominately from in-subbasin releases.
C. Hatchery strays from the northeast Oregon Hatchery Program do not exceed 10% of the abundance of any out-of-basin natural Chinook salmon population.

Management Objective 5: Restore and maintain treaty-reserved tribal and recreational fisheries.

A. Hatchery and natural-origin adult returns can be adequately forecasted to guide harvest opportunities.
B. Hatchery adult returns are produced at a level of abundance adequate to support fisheries in most years with an acceptable level of impact to natural-spawner escapement.

Management Objective 6: Operate the hatchery programs to achieve optimal production effectiveness while meeting priority management objectives for natural production enhancement, diversity, harvest, impacts to non-target populations.

A. We can identify the most effective rearing and release strategies.

B. Management methods (weirs, juvenile traps, harvest, adult out-plants, juvenile production releases) can be effectively implemented as described in management agreements and monitoring and evaluation plans.
C. Frequency or presence of disease in hatchery and natural production groups will not increase above historic levels.

Management Objective 7: Understand the current status and trends of spring Chinook salmon natural populations and their habitats in the Imnaha and Grande Ronde river subbasins.

A. In-basin habitat is stable and suitable of spring Chinook salmon production.
B. We can describe juvenile spring Chinook salmon production in relationship to available habitat in each population and throughout the subbasin.
C. We can describe annual (and 8-year geometric mean) abundance of natural origin adults relative to management thresholds (minimum spawner abundance and ESA delisting criteria) within prescribed precision targets.
D. Adult spring Chinook salmon utilize all available spawning habitat in each population and throughout the subbasin.
E. The relationships between life history diversity, life stage survival, abundance and habitat are understood.

Management Objective 8: Coordinate monitoring and evaluation activities and communicate program findings to resource managers.

A. Coordination of needed and existing activities within agencies and between all co-managers occurs in an efficient manner.
B. Accurate data summary is continual and timely.
C. Results are communicated in a timely fashion locally and regionally.
D. The M&E program facilitates scientifically sound adaptive management of NEOH.

Decision Framework

Applied adaptive management of fisheries resources is inherently a dynamic process. Maintaining effective communications between policy, management, and research level positions is essential in assuring accountability and linking actual project performance into informed and formal fisheries management decision processes (policy level and management level). Establishing a decision framework, including timeframes, prior to management action implementation is desirable. Such a decision framework is targeted as a standard management plan component for the Nez Perce Tribe Department of Fisheries Resources Management. The framework should guide regular consideration to continue, terminate, or modify (approach or expectations) specific management actions. The NEOH management assumptions described above provide the technical link to the decision framework with both base expectations and basic data requirements being prelabeled. If any of the assumptions are proven to be false or subject, either by direct project findings or literature, the project's ability to achieve management goals will be formally considered. Routine assessment for change in program scope (continuation) and direction will be applied as necessary, at a minimum every five years.

EXISTING PROGRAM AND HISTORY

Lookingglass Fish Hatchery was built as part of the Lower Snake River Compensation Plan (LSRCP) to produce spring Chinook salmon for release in the Imnaha and Grande Ronde rivers. LSRCP is a program to mitigate for spring, summer, and fall Chinook and steelhead losses caused by the four federal dams constructed on the lower Snake River. Lookingglass Fish Hatchery was constructed by the U.S. Army Corps of Engineers (COE) in 1982 and turned over to the U.S. Fish and Wildlife Service for operation. Oregon Department of Fish and Wildlife (ODFW) currently operates the facility. Lookingglass Fish Hatchery was initially designed and constructed to produce two stocks of fish; Imnaha stock for the Imnaha subbasin (490,000 smolts) and Lookingglass Creek stock for the Grande Ronde subbasin (900,000 smolts).

Beginning in the early 1990's, co-managers of the LSRCP program (ODFW, Nez Perce Tribe [NPT], and the Confederated Tribes of the Umatilla Indian Reservation [CTUIR]) recognized that these populations were at imminent risk of extirpation and immediate action was necessary. In 1992, Snake River spring/summer Chinook salmon were listed as threatened under the Endangered Species Act (ESA). The Lookingglass Fish Hatchery mitigation program was redirected to a conservation and recovery program. This program is authorized by the National Oceanic and Atmospheric Administration (NOAA-Fisheries) under a Section 10 permit and is referred to as the Currently Permitted Program (CPP). The current goals of the CPP are to produce:

- 490,000 smolts of Imnaha River population origin
- 250,000 smolts of Upper Grande Ronde River population origin
- 250,000 smolts of Catherine Creek population origin
- 250,000 smolts of Lostine River population origin
- 150,000 smolts for Lookingglass Creek of Catherine Creek population origin

Because the total number of fish produced at Lookingglass Fish Hatchery did not change with the CPP, an assumption was made that the existing facility, with minor modifications, would be sufficient to meet the CPP needs. However, each of these programs has associated fish health and monitoring/evaluation needs that require additional space and water. Lookingglass Hatchery was not designed to meet the CPP requirements. Co-managers determined that without additional facilities and significant modifications to Lookingglass Hatchery, production would be reduced under the conservation and recovery programs.

Broodstock Strategy

Co-managers have agreed to a diverse approach for managing Chinook salmon stocks in the Grande Ronde subbasin that includes differing levels of supplementation; high – Upper Grande Ronde River, moderate - Lostine River, low – Catherine Creek, and no supplementation – Minam River and Wenaha rivers. The Grande Ronde Basin Spring Chinook Hatchery Management Plan provides further details of this hatchery intervention approach (Appendix B).

Grande Ronde endemic spring Chinook salmon of hatchery and natural-origin returning to the Grande Ronde Subbasin are used for broodstock. Currently, a dual broodstock strategy is used for supplementation in the Grande Ronde river subbasin. The two components are 1) conventional broodstock (naturally produced adults are collected at weir facilities, transferred to Lookingglass Fish Hatchery, held, and spawned); and 2) captive broodstock (natural parr are collected from streams, reared at Lookingglass Fish Hatchery until the smolt stage, transferred and reared until maturity at either Manchester Marine Laboratory or Bonneville Fish Hatchery, and spawned). Progeny resulting from both broodstock methods are acclimated and released back into their stream of origin as smolts. Co-managers intend to shift to a conventional broodstock-only supplementation program as run strength increases.

Imnaha endemic spring Chinook salmon of hatchery and natural origin are used for broodstock. Hatchery production and initial rearing of Imnaha River Chinook salmon occurs out-of-basin at Lookingglass Fish Hatchery; acclimation occurs at the Imanaha Satellite Facility at Gumboot. The existing artificial propagation program began in 1982 and has always used endemic broodstock throughout its history.

All conventional broodstock spawning for both subbasins occurs at Lookingglass Fish Hatchery. Peak spawning usually takes place during the month of September. All surviving adults retained for broodstock are used. Fertilization involves a spawning matrix that uses the number of ripe males and females available on a specific spawning day. The spawning matrices are used to avoid giving any individual a selective advantage and to maximize the number of genetic crosses.

Pertinent Findings

Ongoing projects have contributed to our understanding of Chinook supplementation in the Imnaha and Grande Ronde subbasins. Findings from these studies to date have given co-managers preliminary information upon which the NEOH program was developed. Prior supplementation efforts with non-endemic hatchery stocks had failed as indicated by low natural escapement and productivity in supplemented streams. Non-endemic hatchery-origin fish strayed at high rates into the Lostine, Minam, and Wenaha Rivers and in some years represented a high proportion of the natural spawners.

No significant differences in life history characteristics between Imnaha natural and Imnaha hatchery fish have been detected, except in adult age-composition. No significant differences in genetic characteristics between natural and hatchery fish have been detected. Co-managers have seen considerable benefit from supplementation in reducing the rate of decline in the Imnaha stock. Natural production of juvenile salmon from adult hatchery fish released in Lick Creek was documented in years when hatchery adults were outplanted.

Initial release strategies at Lookingglass Hatchery were designed to mimic natural fish emigration times from Lookingglass Creek. All sub-smolt release strategies survived poorly. The spring yearling release strategy was the only strategy that consistently produced progeny-parent ratios above 1.0. All other strategies were dropped from production following the study completion.

Two release sizes in the Imnaha basin were evaluated to determine size influence on survival and age structure. We have found no significant difference of survival of smolts released at 30g and 18g. Adults return at a slightly older age for the smaller smolts. Monitoring juvenile emigration through the hydrosystem revealed a consistent survival advantage of natural smolts over hatchery smolts.

Background Reports

Development of the NEOH program involved extensive documentation explaining the need for improvement and change, as well as a summary of historic and current conditions. These planning documents when combined with existing program operational documents such as the Annual Operation Plans (AOP) and Hatchery and Genetic Management Plans (HGMP), provide comprehensive details of program development and history. Documents describing key aspects of the NEOH program include:

- NEOH Spring Chinook Master Plan (Ashe et al. 2000); this document includes the Northeast Oregon Hatchery Spring/Summer Chinook Salmon Conceptual Monitoring and Evaluation Plan (Appendix D in Ashe et al. 2000; Hesse and Harbeck 2000). The conceptual framework was the first part of the overall monitoring and evaluation program developed here in detail;
- NEOH Imnaha and Grande Ronde Spring Chinook Step 2 Submittal Preliminary Design Report (MWH 2001);
- Grande Ronde Spring Chinook Hatchery Management Plan (Zimmerman et al. 2002);
- Imnaha Subbasin Summary (Bryson et al. 2001);
- Grande Ronde Subbasin Summary (Nowak et al. 2001);
- Hatchery and Genetic Management Plan for the Lower Snake River Compensation Plan Imnaha Spring/Summer Chinook Program (LSRCP 2002a);
- Hatchery and Genetic Management Plan for the Lower Snake River Compensation Plan Grande Ronde Basin Spring/Summer Chinook Program (LSRCP 2002b); and
- Lower Snake River Fish and Wildlife Compensation Plan Grande Ronde and Imnaha Basins Annual Operation Plan (LSCRP 2002c).

DESCRIPTION OF PROPOSED PROGRAM

Production Program

Northeast Oregon Hatchery is a conservation program that will spawn, incubate, rear, and release spring/summer Chinook salmon. The hatchery system will consist of three incubation and rearing facilities and three satellite acclimation sites. Juvenile fish will be reared to the smolt stage and released in the Imnaha River, Lostine River, Catherine Creek, Upper Grande Ronde River, and Lookingglass Creek (Figure 4). The hatchery production program (facilities, stream, life stage, number, and location of fish to be released) from NEOH facilities is summarized in Table 1. Hatchery production groups refer to total production for a given tributary. Treatments describe experimental/varied approach for subsets of each production group.

The production goal for Imnaha spring Chinook salmon remains 490,000 smolts. The goal of 250,000 smolts also remains for the Lostine River, Catherine Creek and the upper Grande Ronde. These numbers are unchanged and are authorized by NMFS through Section 10 permits of the Endangered Species Act and established in the Grande Ronde Spring Chinook Hatchery Plan (Appendix B).

Northeast Oregon Hatchery will incorporate some components of Natural Rearing System (NATURES) techniques. A detailed summary of the NATURES design criteria can be found in the NEOH Preliminary Design Appendix B (MWH 2001). NATURES techniques provide juvenile hatchery fish with conditions more similar to those experienced in a natural stream.

Juveniles will be raised to smolts from incubation to release in variable water temperature conditions mimicking the natural regime. Rearing conditions will also include low density (0.1 to 0.13 lb/cf/in), cryptic substrate coloration, instream/water surface structure, and natural photo-period (indoors). Smolts will be acclimated and volitionally released into known natural production areas in their natal stream with the intent that the returning adults will spawn in their natural habitat rather than solely supporting hatchery production and harvest.

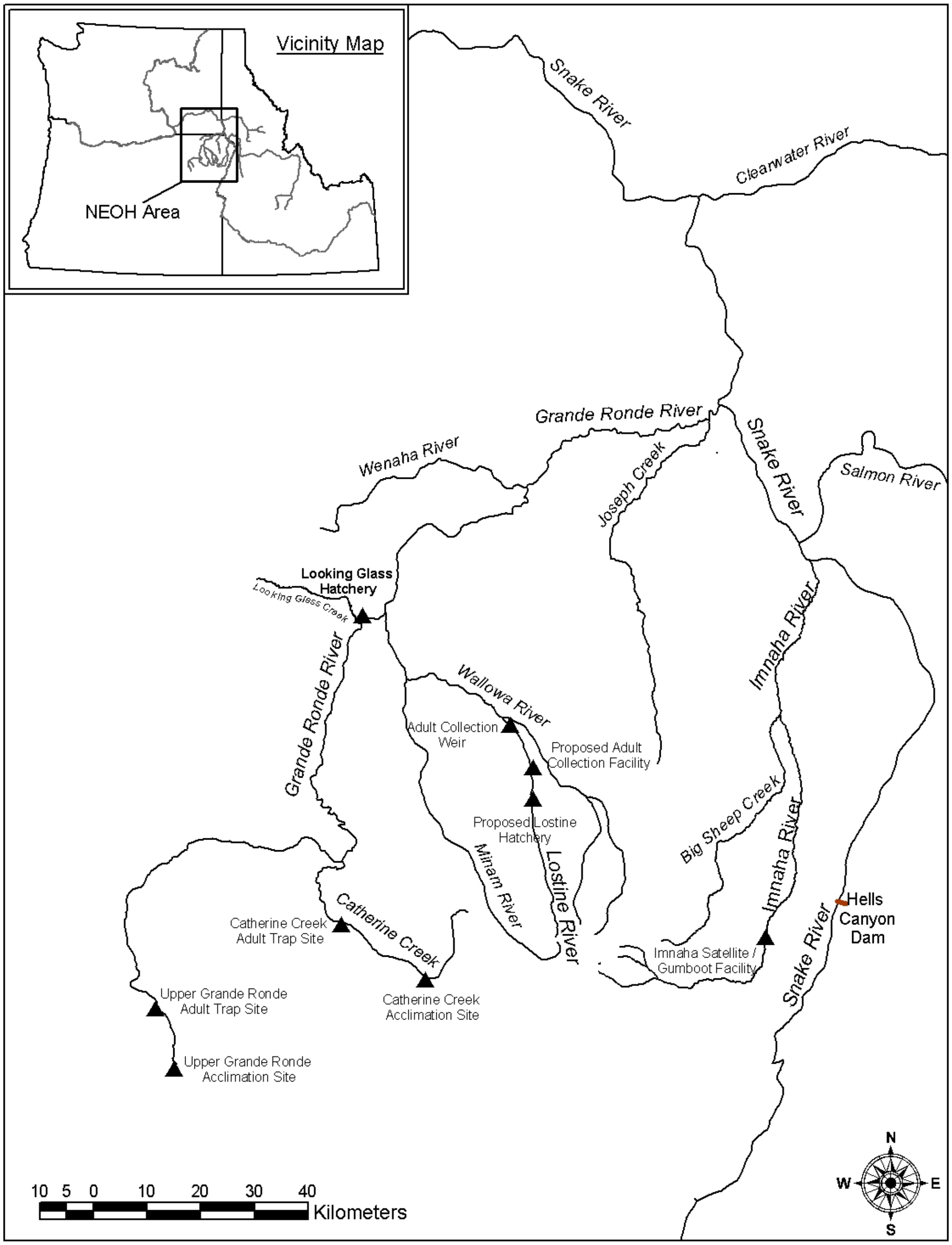


Figure 4. Northeast Oregon Hatchery rearing, acclimation, and adult collection facility locations.

Table 1. Summary of Chinook salmon production proposed for NEOH facilities.

Stock	Brood Source	Treatment	Release Number	Spawning Location	Incubation Location	Early Rearing Location	Number of Early Rearing Containers	Final Rearing	Number of Rearing Containers	Acclimation	Number of Acclimation Ponds
Imnaha	Gumboot Weir	Conventional	245,000	Lostine	Lostine	Lostine	20	Lostine	4-5	Gumboot	1
		Conventional	245,000	Lostine	Lostine/ Lookingglass	Lookingglass	16-20	Lookingglass	4-6	Gumboot	1
Lostine River	Captive Brood	Salt	60,000 – 120,000	Bonneville	Lostine	Lostine	6-12	Lostine	1 -2	Lostine	NA
	Lostine Weir	Conventional	130,000 – 190,000	Lostine	Lostine	Lostine	12-18	Lostine	2-3	Lostine	NA
Catherine Creek	Captive Brood	Fresh	60,000 – 120,000	Bonneville	Lookingglass	Lookingglass		Lookingglass	2-4	Catherine Creek	1-2
	Catherine Creek Weir	Conventional	130,000 – 190,000	Lookingglass	Lookingglass	Lookingglass		Lookingglass	3-5	Catherine Creek	2-3
Grande Ronde River	Captive Brood	Salt	30,000 - 60,000	Bonneville	Lookingglass	Lookingglass		Lookingglass	1-2	Upper Grande Ronde River	1-2
		Fresh	30,000 - 60,000	Bonneville	Lookingglass	Lookingglass		Lookingglass	1-2	Upper Grande Ronde River	1-2
	UGR Weir	Conventional	130,000 – 190,000	Lookingglass	Lookingglass	Lookingglass		Lookingglass	3-6	Upper Grande Ronde River	2-3
Lookingglass Creek	Catherine Creek Weir	Conventional	150,000	Lookingglass	Lookingglass	Lookingglass		Lookingglass	2-3	Lookingglass	NA

Captive Broodstock	Brood Source	Treatment	Collection Number	Parr-to-Smolt Rearing	Smolt -to-Adult Rearing	Spawning Location	F1 Progeny
Lostine River Parr	Lostine River	Saltwater (natural)	300	Wallowa Fish Hatchery	Manchester	Bonneville	See above
Catherine Creek Parr	Catherine Creek	Freshwater (natural)	300	Wallowa Fish Hatchery	Bonneville	Bonneville	See above
Upper Grande Ronde River eggs/Parr	Grande Ronde River	Saltwater (natural)	150	Wallowa Fish Hatchery	Manchester	Bonneville	See above
		Freshwater (natural)	150	Wallowa Fish Hatchery	Bonneville	Bonneville	See above

Proposed Production Summaries

Imnaha River: Artificial propagation of Chinook salmon from the Imnaha River will be supported by adult collection, holding and spawning at the Imnaha Satellite Facility. Eggs will be incubated at this site until eye-up then transferred to Lookingglass Fish Hatchery and Lostine Hatchery location(s) for final incubation and early rearing. Transportation of smolts from Lookingglass Fish Hatchery and the Lostine Hatchery to the Imnaha Satellite Facility (Gumboot) will occur in mid-March for acclimation and release.

Lostine River Production: Co-managers will obtain broodstock for the Lostine River from the captive broodstock program at Bonneville Hatchery and Manchester Marine Laboratory and from the conventional program at the two weir locations in the Lostine River. The entire production program from adult holding to juvenile release will occur at the Lostine Hatchery facility. The Lostine River captive broodstock production will be spawned at Bonneville Fish Hatchery and incubated to eye-up at Oxbow Hatchery. Eyed eggs will be transported to the Lostine Hatchery for final incubation, early and final rearing, and release.

Catherine Creek and Upper Grande Ronde Production: Broodstock for Catherine Creek and the Upper Grande Ronde River will be obtained from two sources. The captive broodstock program will continue to provide F1 progeny for release into their natal streams and adult broodstock will be acquired from the weir locations in Catherine Creek and the Upper Grande Ronde River. The conventional production program for both Catherine Creek and Upper Grande Ronde River (adult holding, spawning, incubation, early and final rearing) will occur at the Lookingglass Hatchery Facility. The Catherine Creek and Upper Grande Ronde River Captive broodstock production is spawned and incubated to eye-up at Bonneville Hatchery. Eyed eggs will be transported to the Lookingglass hatchery for final incubation, early and final rearing. Smolts are transferred to acclimation sites in each respective stream in mid-March for holding and release in mid-April.

Lookingglass Creek Production: Broodstock for Lookingglass Creek will be developed from the Catherine Creek stock. After 2008, known origin adults from Catherine Creek stock returning to Lookingglass Creek will be used to support conventional production specific to Lookingglass Creek. The entire production program (adult holding, spawning, incubation, early and final rearing, and release) will occur at Lookingglass Fish Hatchery.

MONITORING AND EVALUATION APPROACH

MONITORING AND EVALUATION CONTEXT

The Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, and Oregon Department of Fish and Wildlife believe that supplementation may be capable of increasing natural production, but the recovery benefits of supplementation are not universal and can be highly uncertain. Traditional hatchery programs have not always met success in the past. We know that hatchery smolts produced from localized salmon stocks perform better than hatchery smolts from distant stocks (Reisenbichler 1988), successful outplanting of hatchery-origin fish depends on the hatchery's ability to produce fish qualitatively similar to natural-origin fish (Lichatowich and McIntyre 1987), genetic fitness decreases as differences between hatchery and wild fish increase (Chilcote et al. 1986), and the production of wild stocks can be reduced after the introduction of poorly adapted fish (Vincent 1987). Therefore, monitoring and evaluation are integral in managing the risks associated with supplementation.

One role of a monitoring and evaluation program is to resolve project uncertainty since critical uncertainties often serve as a pretext for inappropriate management actions. Uncertainty is a function not only of unpredictability and ecosystem randomness but also of our state of knowledge and scientific understanding. Therefore, monitoring and evaluation have long been recognized as necessary components of natural resource management. Monitoring and evaluation activities are intended to address project uncertainty and to provide feedback for proper adaptive management (NPPC 1999). Thus, the monitoring and evaluation plan serves as an adaptive management tool for assessing the utility of supplementation as an endangered species recovery method. This plan will address the uncertainty specific to hatchery intervention in the Imnaha and Grande Ronde subbasins and in general, add to our knowledge regarding supplementation.

The importance of monitoring natural resource status and assessing the impact of management actions is also emphasized by multiple science groups (Botkin et al. 2000; Hesse and Cramer 2000; ISRP 2001, McElhany et al. 2000). Monitoring and evaluation activities then, should describe program status and provide feedback to managers (Steward 1996, NPPC 1999). This is accomplished through annual monitoring of population trends, quantifying population abundance, small-scale studies, and controlled setting experiments. Feedback consists of collecting information describing with analytical and predictive power the distribution, condition, status, and trends of biological and environmental variables of interest. Management then has current data on a continuous basis in which to properly evaluate program effectiveness. Moreover, well-coordinated management actions, when coupled with relevant monitoring and evaluation programs, can reduce uncertainty about the effect of those actions on target and non-target populations.

MONITORING AND EVALUATION GOALS AND OBJECTIVES

It is essential that the goal of any monitoring and evaluation effort be clearly defined as a means of evaluating the relevance of the program. As stated in the Conceptual Plan (Hesse and Harbeck 2000), the goal of this monitoring and evaluation effort is:

To monitor the status of northeast Oregon spring Chinook salmon populations and habitat and evaluate the results of the NEOH program so that operations can be adaptively managed leading to optimal hatchery and natural production and at the same time minimize adverse ecological impacts.

This goal is simple and unambiguous, it relates directly to co-managers' desire for the subbasins, and it can be measured and assessed through monitoring (Bisbal 2001). This goal forms the basis for choosing M&E activities that will define and measure the progress of the NEOH program. Within the goal, co-mangers acknowledge two NEOH program components that direct M&E activities:

- ESA recovery/population sustainability - Monitor and evaluate abundance, distribution, genetics, and ecological interactions, so that hatchery operations can be adaptively managed to maximize contribution and minimize negative impacts to listed species and ecosystem functions.

- Mitigation/Harvest - Monitor adult abundance in relation to escapement thresholds (minimum adult spawner escapement, ESA recovery, carrying capacity) to guide harvest opportunities of spring Chinook salmon throughout the entire Columbia River basin, specifically including the Imnaha and Grande Ronde subbasins.

Monitoring and evaluation objectives developed from the monitoring and evaluation goal are embedded in the "methodology" chapter and are associated with relevant management objectives. The M&E objectives focus on the essential characteristics and conditions of the NEOH populations of interest and describe management outcomes as reflected in those populations. A suitable experimental design then requires identification of various indicators or <u>performance measures</u> that are sensitive to natural events or human manipulation and are useful in judging performance according to specific M&E objectives (Cairns et al. 1993).

EXPERIMENTAL DESIGN

The Independent Scientific Advisory Board (ISAB) outlined data needs and experimental designs for the evaluation of supplementation (Bilby et al. 2003). They described a three-tiered approach to monitoring involving trend analysis, statistical inferences from appropriate performance measures and experimental research. Trend monitoring requires repeated measurements within a consistent landscape to quantify change over time. Statistical monitoring can help provide conclusive information regarding management actions and experimental research can establish cause and effect (Hillman 2003). Ecosystems that support spring/summer Chinook salmon are highly open and interconnected. It follows that key indicators or performance measures should be broad in nature and involve the entire life cycle of salmon. An integrated monitoring system of multiple tiers is broad in nature and greatly enhances an M&E plan.

In addition, the Independent Science Review Panel (ISRP) recommended viewing supplementation projects as a large-scale manipulative experiment and testing the major hypotheses associated with supplementation as a rebuilding and recovery tool. Variables to be tested in a population and supplementation assessment should include adult escapement, smolt yield, smolts-per spawner, harvest, and trends in these statistics over time periods that define the productivity and capacity of the system (ISRP 2002).

The National Marine Fisheries Service (NOAA) also recommended characterizing viability of populations by abundance/productivity, diversity, spatial structure, and habitat capacity. Baseline information on population status should be monitored in all spawning populations (McElhany et al. 2000). The spatial scale to be monitored by M&E programs should vary depending on the functional structure of the population and range of potential management actions (Schlosser and Angermeier 1995; Montgomery 1995).

Achieving or maintaining a desired level of returning adult salmon, as well as other aspects important to natural sustainability, form the basis for most management and conservation monitoring programs. The Validation Monitoring Panel (Botkin et al. 2000) provided a science-based analysis for monitoring salmon populations. The panel identified the need for adult salmon abundance information in relation to conservation and restoration. Monitoring and evaluation programs can accomplish this through direct census or estimation techniques. Tracking population trends with indices of relative abundance also provides valuable management information (Botkin et al. 2000).

Based on these recommendations, co-managers have designed and will implement a monitoring and evaluation program to address management objectives and answer questions fundamental to Chinook salmon mitigation and recovery in northeast Oregon. We will examine performance measures between hatchery and natural-origin fish using multiple spatial scales, and comparisons within and between treatment streams, as well as between supplemented and non-supplemented populations. We are very interested in relative performance of the hatchery fish compared to their naturally produced counterparts and their ability to integrate into the natural population without adverse effect. The approach uses a combination of comparative performance testing, small-scale experiments, and population status monitoring.

Comparative Performance

We propose to collect performance measure data that will describe differences or similarities between two or more groups of fish. Comparative performance testing, also called "effectiveness monitoring", will occur primarily within individual streams or between treatment and reference streams. Paired comparisons will be tested at multiple life stages and involve treatment vs. natural, treatment vs. predicted performance, treatment vs. treatment and treatment vs. reference combinations. Relative performance across streams will be examined for both hatchery and natural production groups. Primary replication will occur across years within a facility or stream. Five annual replicates will be used to examine the variability in comparative tests.

Possible causal factors will be investigated through these comparative studies. However, the ability to statistically attribute cause and effect will be somewhat limited due to highly variable environmental conditions and low number of replicates (ISRP 2003). Results that describe the effectiveness of management actions will involve inference gained by replicated results across facilities and streams. Comparative experimental designs that co-managers believe will prove useful are repeated measure designs (Before /After and Treatment vs. Reference) and small scale studies.

Before/After

Approaches to a "before and after" experimental design, as they relate to spring Chinook supplementation programs, are thoroughly discussed by Steward (1996). This design requires baseline performance measure data prior to supplementation. Performance measure information continues to be collected as response variables after supplementation begins. Sampling times are considered replicates. To help partition variability, a block design where streams are blocks is used to evaluate supplementation effects. Temporal variability within pre- and post-treatment periods is assumed to be less than the variability between steams. The major H_0 of interest is "no change in supplemented streams." Many pre-operational M&E activities were conducted prior to supplementation in the Lostine and Upper Grande Ronde rivers and Catherine Creek. Results from pre-operational monitoring and evaluation have revealed much about the salmon populations in these streams. This information gives co-managers a retrospective or historical context for evaluating supplementation.

However, co-managers realize there are limitations to a "before and after" experimental design that should be considered when implementing a monitoring and evaluation plan. Although temporal controls are included (pre-treatment measurements), it may be difficult to prove a supplementation effect if some other extraneous effect is occurring at the same time. Therefore, Steward (1996) and Bilby et al. (2003) recommend that a "before and after" experimental design include paired treatment and reference streams for improving hypothesis testing. "After" period is defined here as conditions existing while release of hatchery-origin fish is occurring. This differs from the Idaho Salmon Supplementation Studies application where "after" period represents the period when releases of hatchery fish are terminated.

Treatment/Reference

References are a necessary component of experiments because they provide observations under normal but varying conditions without the effects of the treatment. The references, then, offer the standard by which the results are compared. Thus, to explicitly test supplementation as a recovery tool, it is necessary to compare the treatment (supplemented) stream against a comparable but untreated stream (Bilby et al. 2003).

Although the concept of a "traditional" experimental control appears valuable, there are no true control streams available in the subbasin. Therefore, we use the term "reference stream" as an adaptation of the control stream concept. A true control stream would have the same characteristics as the treatment stream, but not receive the treatment being applied to the treatment stream. In the Grande Ronde and Imnaha subbasins, there are many unique aspects of each tributary that cause them to differ from one another. Because of management considerations and the limited number appropriate streams, our treatment and reference selections could not be entirely random. The reference streams tend to be located in more pristine habitat with fewer negative anthropologic impacts (*Table 2*).

Deviations from the true "control stream" concept may eliminate the statistical advantages to a treatment-vs-control design, because the statistical advantage is only achieved if all factors influencing treatment success are varying in parallel between the treatment and control streams.

So, if randomization and true controls are not possible in a large ecological study like NEOH, then it is critically important to replicate treatment/reference in multiple locations. Legitimate information can be gained through standardization of methods and data collection procedures (Bilby et al. 2003).

Recognizing the weaknesses of treatment-vs-reference comparisons in the Imnaha and Grande Ronde subbasins, the experimental design depends on other techniques for detecting treatment effects. However, elements of the "before and after" and treatment-vs-control design have been incorporated into the NEOH M&E Plan wherever those elements offer reasonable advantage to assessing NEOH benefits and impacts. The plan incorporates the Minam and Wenaha rivers as internal reference streams and the Secesh River and Marsh Creek as external reference streams. These streams have natural spring Chinook populations that will not be supplemented. Surveys will continue on these reference streams. The M&E program will employ these reference streams in a pair-wise fashion to provide inference on the gross level of impact/effectiveness absent supplementation. Analysis of varied pairings will occur over time relative to historical correlation of population trends and contemporary conditions related to habitat condition and management actions.

Table 2. Treatment and reference streams for Chinook salmon population status monitoring associated with the Northeast Oregon Hatchery program.

Stream	Treatment /Reference
Imnaha River	Treatment
Wenaha River	Reference
Minam River	Reference
Lostine River	Treatment
Upper Grande Ronde River	Treatment
Catherine Creek	Treatment
Secesh River (South Fork Salmon River)	Reference
Marsh Creek (Middle Fork Salmon River)	Reference
Snake Basin Aggregate	Reference

Small-scale Studies

Although most evaluations will focus primarily on the population scale, additional small scale or short-term studies will be conducted to examine specific issues that require intensive or controlled study design attributes. These investigations will be designed to confirm or reject hypotheses concerning certain mechanisms and effects of supplementation. Small-scale manipulation experiments can provide a way of isolating the effects of a few important ecological processes and components from more complex ecological interactions (Peterman 1990). They are intended to be relatively short-termed and will be carried out in select streams or controlled field environments.

These types of small-scale experiments (research) fit the classical hypothesis-testing format and will be generally limited spatially and temporally (i.e. reproductive success studies using DNA parentage analysis, isolated adult spawning behavior and performance or feed study to reduce jacking in hatchery fish).

Status and Trend Monitoring
The objective of status and trend monitoring is to simply describe existing conditions and provide evidence of change over time. The NOAA Fisheries RME Plan (NOAA 2003) calls for status monitoring to document progress toward recovery of listed populations. Controls are not required in status monitoring because cause-and-effect relationships are not sought. Repeated measurements (temporal replicates) are taken over time to quantify change. Existing population conditions are compared to performance standards as established in the 2000 FCRPS Biological Opinion or to prior conditions to track the trends.

Our status and trend monitoring will provide key performance measure information for the supplemented natural populations, the reference populations and the greater metapopulations of northeast Oregon. Quantification of these performance measures replicated over time and space will offer evidence for general conclusions regarding the status of northeast Oregon Chinook salmon populations in terms consist with NOAA guidelines (McElhany et al. 2000). The Imnaha subbasin is the priority area for this monitoring on a regional scale.

Spatial Scale
The variability of physical and biological components of an ecosystem occurs at multiple spatial scales (Bisbal 2001). Additionally, management actions and resource status reviews occur on multiple spatial scales. Therefore, it is necessary to monitor at different spatial scales. Scales that are very fine for some performance measures may be too variable to give meaningful results. Scales that are too course for certain performance measures may lack sufficient sensitivity to detect change. Thus, monitoring on different spatial scales is dependent on the performance measure of interest (Botkin et al. 2000). We have categorized our monitoring spatial scales based on Jordan et al. (2002).

<u>Subbasin-wide</u> – Information from monitoring at this scale provides a basis for interpreting subbasin-level multiple population data. At this spatial scale, the primary objective is to develop a general understanding of Chinook salmon abundance and distribution. The data collected by this type of monitoring will be used to assess fish abundance and trend by subbasin, assess the status of watershed health, and associate watershed condition with population status and processes (Jordan et al. 2002). Probabilistic sampling will be applied specifically for, spatial and temporal distribution of juvenile Chinook salmon, spatial distribution of adult spawning, and physical habitat. This level of monitoring supports Tier II evaluations as described by NOAA, CBFWA, and BPA.

<u>Population</u> - Monitoring on a tributary scale or according to population (primary spawning aggregates) should include all potential spawning and rearing habitat. Populations represent the core areas currently supporting significant natural production and include both treatment and reference streams (*Table 2*). At this scale, monitoring and evaluation are more closely related to the experimental treatments and performance measures needed to address questions regarding specific streams. Designated reference streams are also monitored at this scale. Although use of treatment and reference streams supports status monitoring, these streams are not all inclusive of escapement and natural production subbasin-wide. All TRT identified populations in northeast Oregon are included in this Tier II level monitoring.

Key areas – Key areas represent subsets of treatment and reference streams down to reaches within a given stream. At the reach or key area level, the information being collected is often dictated by the management actions or habitat attributes being evaluated (Botkin et al. 2000). Definition of specific key areas as they relate to performance measures occurs in the methodology sections of this plan. Key area structure supports Tier III comparative hatchery performance testing and small-scale experiments.

Experimental Production Unit

The ultimate evaluation point for the NEOH hatchery product is adult hatchery return and the associated characteristics of that return. The experimental unit for hatchery production treatment groups that influence adult returns is the individual final rearing pond. The ponding design of the facility should provide enough flexibility to test management assumptions that will answer current questions as well as questions that might arise in the future. Co-managers will consider the number of fish needed to achieve sufficient returns for statistically significant results, the number of unique or replicated experimental units within a treatment group, and the number of treatment groups from different production strategies.

In Appendix C we describe hatchery design attributes that support segregated rearing of two treatment groups (three desired for Imnaha production) per stock. We also describe a need for additional segregated rearing to accommodate fish heath management. The support of adaptive management is a cornerstone aspect of the M&E program. As such, comparative performance of alternative production strategies is essential. Without comparative results, efforts to improve performance constitute a "trial and error" approach (ISRP 2000-9). We feel that concurrent evaluation of two or three production strategies maintains a balance between excessive fine-tuning and meaningful guidance as described by the ISRP (ISRP 97-1).

The number of fish needed per experimental unit to assure adequate statistical power for evaluation varies in relation to the survival rate. De Libero (1986) established a mathematical relationship between the precision of recoveries against observed recoveries. As a general rule, 30 to 35 tag recoveries are needed to provide evaluation with a reasonable chance to detect change (Figure 5). At very low rates of return (0.03% SAR), experimental release groups of 100,000 are required to provide adequate returns (*Table 3*.) But co-managers have not seen SARs that low for most Imnaha hatchery cohorts. Therefore, establishing an experimental unit or release group size that will provide adequate recoveries 80% of the time is sufficient. Recoveries from past CWT tag releases have provided co-managers with the information necessary to estimate SARs. The PSMFC recommends release groups of 60,000 Chinook salmon to obtain significant recoveries. If SARs are consistently high (>0.5%), release groups as low as 20,000 to 25,000 would be sufficient for evaluation. Tag recoveries from the hatchery or river of origin are most desirable for program evaluation. However, tag recoveries in the ocean and river are also desirable when fisheries are conducted out of the subbasin.

Table 3. Expected number of returning adults at various sizes of release groups and a range of survival rates. Highlighted areas represent minimum level of return desired to enable adequate evaluation.

Survival Rate (SAR %)	Release Group Size 25000	40000	50000	60000	75000	100000
0.03	7.5	12	15	18	22.5	30
0.05	12.5	20	25	30	37.5	50
0.07	17.5	28	35	42	52.5	70
0.09	22.5	36	45	54	67.5	90
0.11	27.5	44	55	66	82.5	110
0.13	32.5	52	65	78	97.5	130
0.23	57.5	92	115	138	172.5	230
0.33	82.5	132	165	198	247.5	330
0.43	107.5	172	215	258	322.5	430
0.53	132.5	212	265	318	397.5	530
0.63	157.5	252	315	378	472.5	630
0.73	182.5	292	365	438	547.5	730
0.83	207.5	332	415	498	622.5	830
0.93	232.5	372	465	558	697.5	930
1.03	257.5	412	515	618	772.5	1030
1.13	282.5	452	565	678	847.5	1130

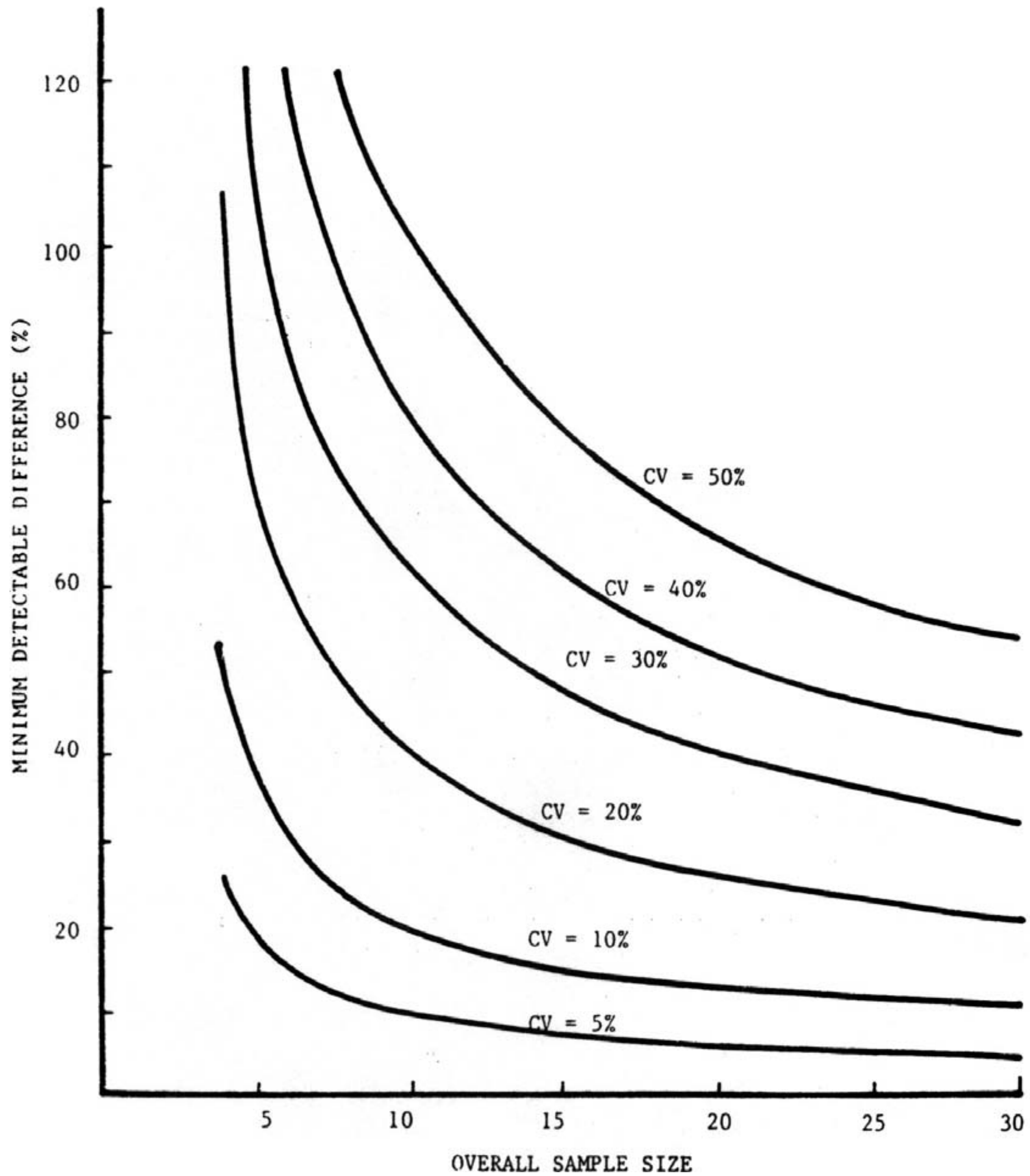


Figure 5. The effect of overall sample size in balanced pre and post impact study on minimum detectable difference (ß = 0.2) for different levels of variability (CV). Taken from Lichatowich and Cramer (1979).

Statistical Considerations

The first requirement of stewardship is to know the resource. Much of what we know about fisheries comes from our observations and deductive reasoning based on those observations. The Chinook salmon populations that we work with in the Grande Ronde and Imanha have certain characteristics in which researchers and managers are interested. Whether they're abundance indices, life history traits or other characteristics, we want to know the nature of these population attributes, to detect change, and be able to interpret meaning (status and trend monitoring). In addition, we conduct investigations to measure the response of those populations to a management strategy such as supplementation and determine effect or difference (effectiveness monitoring).

It is the collective performance measures detailed in the next section of this plan that will provide information concerning status, trend and effectiveness. To describe performance measure data or infer proper meaning requires the use of statistics. The ability to expresses relative statistical certainty with associated performance measures and comparative tests should be fundamental to this monitoring and evaluation plan.

<u>Precision, Accuracy, and Bias,</u>

If the statistical data collected are to be informative regarding the Chinook salmon populations of the Grande Ronde and Imnaha, our performance measure "samples" ought to be accurate, precise and unbiased. A performance measure that is determined or calculated inaccurately repeatedly in the same manner will be biased. Furthermore, an entire study can be biased if it systematically favors certain outcomes. The terms "accuracy" and "precision" are not synonymous. Accuracy is the closeness of a measured value (performance measure) to reality. Precision refers to the closeness of repeated measurements of the same item (Gunderson 1993). However, because accuracy is rarely knowable, a measure of precision is commonly used to provide assurance of repeatability and assurance that no unsuspected bias exists with the measure.

Precision is a measure of variation associated with a sample from a population and its descriptive statistics (Lockwood and Hayes 2000). Therefore, an essential consideration when collecting performance measure data is an appreciation of variability. Variability in data greatly affects our ability to show differences between groups or to detect change. A robust study design will then take into account all sources of variability associated with performance measures (Hillman 2003). For a large, subbasin study like NEOH, the best approach is one that accounts for all known sources of variation not associated with treatment differences (supplementation). To help partition variability, some hypothesis testing will use a block design. The assumption is that variability of treatment effects within blocks will be less than variability among blocks (Steward 1996).

Statistics of variability are commonly expressed as variance, standard deviation, standard error and coefficient of variation (Lockwood and Hayes 2000). Co-managers will present performance measure statistics with estimates of precision whenever possible. The coefficient of variation (CV) is frequently useful when comparing variability between two or more samples. The CV is a relative measure of variation, in contrast to the standard deviation, which is in the same units as the observations. Since the CV is the ratio of means, it is independent of the unit of measurement, is not influenced by differing samples and therefore an unbiased estimate of error (Steel et al. 1997). Some level of precision may be more acceptable for a particular performance measure than others. The precision needed to detect change or differences within a five-year period will be determined for performance measures vital for management decisions. For performance measures described as percentages (i.e. life stage specific survival) or related to key management thresholds (adult abundance relative to recovery measures) desired precision using 95 % confidence intervals will be considered to bracket the true population value within a range.

Whenever possible, co-managers will improve the accuracy and precision of our performance measures by:

- Sampling across all potentials (time, condition, etc.)
- Using the same measurement method
- Using the same people when sampling
- Randomizing the sample
- Increasing the sample size

<u>Sampling Adequacy and Statistical Power</u>

Fisheries scientists rarely observe an entire fish population. We sample a subset of the population and make judgments based on that sample. Thus, sample size determination is an important consideration in M&E plans and is generally a compromise between precision and the cost of data collection. Sample sizes for NEOH performance measures will be defined by the degree of precision desired, the magnitude of trend co-managers wish to detect, the statistical test and variability inherent in the data. But the primary factor that determines sample size is precision. The more precisely performance is measured the greater number of samples will be required. NEOH co-managers will control precision and conversely risk in decision making by determining the two statistical settings of "alpha" and "power". The alpha level specifies a level of uncertainty in the performance measure. It represents co-managers willingness to risk incorrect conclusions based on the data (rejecting a null hypothesis when it is actually true). The less willing co-managers are to miss a change, difference or trend in the NEOH salmon populations the higher the alpha setting and consequently the more samples needed. Performance measures will be tested with the traditional 0.05 alpha level unless co-managers conclude a greater risk (and fewer samples) is defensible for a particular measure.

Status and trend monitoring will also require NEOH co-managers to specify a minimum rate of change to detect and a minimum time period over which to detect those changes. The smaller the change or difference in the Chinook salmon populations co-managers wish to detect, the greater the number of samples will be required. In addition, the fewer the number of years over which co-managers would like to detect a trend, the greater number of samples they will need. Effectiveness monitoring requires the testing of statistical hypotheses. To determine statistical significance, effect size and power should also be considered (Hillman 2003).

Statistical power is the probability that a statistical test will result in statistical significance and properly detect a true difference or treatment effect (Lockwood and Hayes 2000). Statistical power is directly proportional to sample size. When sample sizes are too small, significant differences may be missed and treatments may be seen as ineffective. Peterman (1990) and Cohen (1988) suggest that fisheries managers should set the statistical power of their tests at 0.80 ($1-\beta$) when conducting research. NEOH co-managers will follow their recommendation.

A final consideration here is the difference in sensitivity between performance measures. Sensitivity is the probability of detecting a change in a performance measure given set alpha and power levels and sample size. NEOH co-managers fully recognize that our ability to detect change will require differing time commitments for different performance measures. Lichatowich and Cramer (1979) conducted sensitivity analysis over a diverse set of performance measures and calculated the magnitude of change that could be detected over time. Likewise, Marmorek et al. (2004) summarized a variety of salmonid studies and tabulated the number of sampling years required to detect changes while achieving 80% statistical power in performance measure testing. Both authors found performance measures associated with abundance and survival had low sensitivity to quickly detect change and will require many years of monitoring (5-30 years depending on magnitude of change). Performance measures associated with life history traits were found to be more sensitive and required fewer years to detect change. NEOH researchers will be cognizant of these differences when reporting results in the ensuing years.

There are a number of software packages available for power analysis and to estimate sample size. NEOH researchers already use several of these programs, e.g. SURPH Sample Size program (Smith et al. 1994). More recent packages include PASS, nQuery Advisor, Stat Power, Sample Power and Systat. Some are freeware or shareware and others are commercially available for a price.

Hypothesis Testing and Biological Meaning

Descriptive statistics such as mean length, weight, fecundity, age-at-maturity, median migration dates, etc. and their associated variation, standard deviation, degrees of freedom, and confidence intervals will be estimated using standard procedures described by many (Snedecor and Cochran 1980; Zar 1984; Steel, et al. 1997; Norusis 1999). However, we also will use *inferential statistics* for hypothesis testing in which to compare groups or samples. Therefore we will use the full range of descriptors including reports of primary data and thorough statistical description of derived performance measure metrics in addition to the more traditional hypothesis testing to determine biological meaning.

Hypothesis testing does provide an objective framework for making decisions about our observations and sample data. It is important to know the statistical significance of a result, since without it there is a danger of drawing conclusions from performance measures where the sample is too small to justify such confidence. Nevertheless, statistical significance and biological significance are not always the same thing. Statistical significance does not indicate the size of the effect. That is why NEOH co-managers will also consider "effect size." Effect size is a measure of biological significance (Thomas and Juanes 1996).

Effect size is a way of quantifying the biological difference between two groups. For example, if one Chinook salmon population has had a supplementation treatment and the other reference population has not, then the effect size can be a measure of the effectiveness of the treatment. In the context of hypothesis testing, effect size is the difference between the null and alternative hypotheses (Thomas and Juanes 1996). It is frequently calculated as the difference between means divided by the common standard deviation (Hillman 2003). NEOH researchers will report effect size as well as results from hypothesis testing to ensure statistical and biological meaning is understood.

MONITORING AND EVALUATION METHODOLOGY ACCORDING TO MANAGEMENT OBJECTIVE

Organization of the methodology section is structured by:

MANAGEMENT OBJECTIVE
Monitoring and Evaluation Objective
Hypotheses or Descriptive Monitoring Attributes
Performance Measures Required
Statistical Tests Applied
Duration/frequency
Spatial Scale of Application
Methods for Data collection and summary

For each Management Objective determining whether the assumptions are met (valid) requires expression of the assumption in quantifiable terms. The management assumptions form the basis of the Monitoring and Evaluation Objectives. Testable hypotheses or descriptive measures are then identified. Key and associated performance measure(s) to be quantified are described followed by the general statistical test(s) to be applied. We provide guidelines for the duration and frequency of sampling required as well as the spatial scale for assessment. We then describe specific data collection methods for each performance measure. For each major category of methods applied a reference number is provided to help link methods utilized over multiple M&E objectives. The form of the methods tracking number is; (Management Objective Number (1-8), M&E Objective letter (a-…), methods for major data collection activities (1…). For example, 2.b.3 refers to the 3rd method under the second M&E objective addressing management objective 2.

MANAGEMENT OBJECTIVE 1: MAINTAIN AND ENHANCE NATURAL PRODUCTION IN SUPPLEMENTED SPRING/SUMMER CHINOOK SALMON POPULATIONS IN THE IMNAHA AND GRANDE RONDE RIVER SUBBASINS.

Monitoring and Evaluation Objective 1a: Determine and compare productivity of hatchery and natural-origin fish in Imnaha, Lostine, and Upper Grande Ronde rivers and Catherine Creek.

Ho: Progeny-per-parent ratio of hatchery-origin fish over time is equal to that of natural-origin fish for each stream.
Ha: Progeny-per-parent ratio of hatchery-origin fish over time is greater than that of natural-origin fish for each stream.

Ho: Progeny-per-parent ratio is equal between streams (or the levels of supplementation intensity) regardless of fish type (hatchery vs. natural-origin fish).
Ha: Progeny-per-parent ratio is significantly different between streams (or the levels of supplementation intensity) regardless of fish type (hatchery vs. natural-origin fish).

Ho: Progeny-per-parent ratio of hatchery-origin fish is the equal to that of natural-origin fish across streams (or the levels of supplementation intensity).
Ha: Progeny-per-parent ratio of hatchery-origin fish is significantly different from that of natural-origin fish across streams (or the levels of supplementation intensity).

The key performance measure is progeny-per-parent ratio (P:P) quantified within a tributary for natural-origin fish and hatchery-origin fish independently. This is a derived value. Calculation of P:P relies on annual run reconstructions and requires quantification of adult abundance to tributary (escapement), index of spawner abundance (redd counts), spawner abundance (spawner), fish per redd, hatchery fraction, age class structure, age-at-return, adult spawner sex ratio, prespawning mortality, and in-tributary harvest. Progeny are quantified through run-reconstruction. Natural fish P:P use two variants of parents; estimated escapement and spawners. Hatchery P:P are generated from the number of parents collected for broodstock by brood year and resulting hatchery returns to the parent stream. P:P ratio will be calculated for total adult contribution (adult-to-adult) and by female contribution (female-to-female).

Testing of results for significantly greater rate by hatchery-origin fish applies a pair-wise one-tail t-test comparison of hatchery P:P to natural P:P by brood year (cohort) within each tributary over time. Time (year) plays a role of 'pair'. Characterization of variability over time within each stream will require replication over 5 year periods.

We also desire to test across streams (or the levels of supplementation). In this case, we are interested in testing additional null hypotheses. In testing these hypotheses, we check the main effect of stream, whereas in testing the second hypotheses, we first check the interaction term between stream and fish type. Graphically, the second null hypothesis says that P:P ratio of hatchery fish over streams is parallel to that of naturally produced fish. Return years are replicates. To test these hypotheses at the same time, two-factor analysis of variance (ANOVA) is appropriate, where two factors are fish type (hatchery fish vs. naturally produced fish), and stream (or the level of supplementation intensity).

We will test at 5% Type I error (i.e. $\alpha = 0.05$), and show the p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

Monitoring of P:P ratios is a long-term process which should continue until the program achieves equal or stable performance for two complete generations (assumption of consistent program operations). Changes in hatchery program operations must be accompanied by monitoring of P:P ratios. Assessment of the this M&E objective will occur in all treatment streams; Imnaha River, Lostine River, Catherine Creek, Upper Grande Ronde River, and Lookingglass Creek.

Methods

1.a.1 - *Adult abundance to tributar*y is defined as the number of mature adult fish (including jacks) to a watershed mouth (or defined area) by age, origin, and sex. This performance measure includes; fish removed by in-tributary harvest, fish removed for broodstock, fish remaining in areas outside (downstream) of the assessment point, and expanded for in-tributary prespawn mortality (if the estimated index is measured post-escapement). Associated performance measures of age class structure, hatchery fraction, adult spawner sex ratio, redd counts, and harvest support refined characterization of escapement attributes (run reconstruction).

Mark-recapture methods are utilized to estimate escapement into the Imnaha, Lostine, upper Grande Ronde rivers and Catherine creek (Figure 4). Weirs target direct enumeration but are typically not 100% efficient due to non-operation periods during high flows. Fish captured, marked, and released at weirs serve as the initial mark group. Carcass collections during multiple pass spawning ground surveys serve as the second (recapture) sampling period.

It is likely that weir/trap operation will be discontinuous due to high flow and debris. Depending on the relationship of the non-operation dates to run timing and the period of time traps are not operated variable assumptions could be violated. Testing of the assumptions and selection of the most appropriate mark/recapture approach will be done on an annual basis. Unbiased estimates of population abundance can be achieved with as few as four recaptures (Cousens et al 1982). Adjusted Peterson (Chapman 1951; Seber 1982), and Scheafer (1951) estimates are commonly used but biased if assumptions are not met (Cousens et al 1981). McGregor et al. (1991) used stratified population estimation (Chapman and Junge 1956; Darroch 1961) due to the ability to accommodate varying capture probabilities in tagging and recovery. We will use this approach and stratify upstream trapping time periods if our chi-square tests of recoveries over time are violated. Stratified abundance estimates have larger confidence intervals than un-stratified. Cappiello and Bromanghin (1997) used a coefficient of variation to describe the relative accuracy and precision of the multiple population estimates. They suggest that methods should be tested under low abundance levels, due to increased needed accurate and precise estimates of minimum escapements. Rajwani and Schwarz (1997) address adjustment of estimates for missed tags in salmon escapement surveys. We do not believe that missed tag identification is an issue with our study design.

We track the number of opercular punched fish released at each weir. Jacks are marked and recovered, but these fish are subtracted out because of potential bias. The bias is due to under-representative recovery of jack carcasses consistently over time and space. Numbers of punched and non-punched carcasses recovered above the weir on spawning ground surveys are tallied. Any recoveries of punched fish below the weir are subtracted out of the released number because they were not in the area above the weir (we assume equal distribution and probability of recovery). With carcass recovery information we calculate a population estimate (which only includes adults). Typically the Chapman's modification of the Peterson estimate has been used. The terms in the equations are:

Released = The number of opercular punched adults released above the weir and possible to recover (*i.e.* does not include fish found below the weir).
Recovered = The number of opercular punched carcasses found above the weir.
Total Carcasses = The total number of carcass recoveries above the weir.

$$\text{Population Size} = \frac{(\text{Released}+1)(\text{Total Carcasses}+1)}{(\text{Recoveries}+1)}$$

The 95% confidence interval for this estimate is calculated as:

$$95\%\ \mathrm{CI} = 2 * \sqrt{\frac{(\text{Population Estimate})^2 (\text{Total Carcasses} - \text{Recoveries})}{(\text{Total Carcasses} + 1)(\text{Recoveries} + 2)}}$$

Weirs are operated from mid April through late September, or ten days after the last fish is captured. Operation dates will be adjusted for migration timing in individual tributaries. Installation of weirs may be as early as January, to include steelhead escapement assessment. Fish trapped at weirs will be enumerated, measured, scale and genetic tissue sample collected; examined for marks/tags and gender; and given an identifying mark. If escapement exceeds processing abilities, representative sub-sampling will be implemented via a stratified random approach. To date, returns have not exceed processing abilities. Depending on small-scale study designs, sub-sampling of length, scales, and genetic tissue samples will be implemented. Captured fish are either released above the weir or transferred to a holding pond for broodstock. Non-target species will be measured (minimum sub-sample 25/day/species) and released.

Some level of spawning occurs downstream of weirs in all treatment streams. Expansion of escapement estimates for comprehensive tributary coverage is calculated by multiplying the fish per redd point ratio estimate (see 1.a.3) by the number of redds downstream of the weir (see 1.a.2). If tributary harvest occurs (typically restricted to areas downstream of weirs) the harvest estimates (see 5.b) are summed with the expanded redd counts and estimate escapement upstream of the weir for a reconstructed measure of adult abundance to tributary.

Weirs are currently operated on all the treatment streams. Improvement of the existing weir structures in the Imnaha and Lostine rivers to facilitate operation over the entire run spectrum is supported under the NEOH program.

1.a.2 – Redds are enumerated as an *index of spawner abundance* via multiple pass spawning ground surveys with extensive area counts. Redds are directly enumerated and generally summarized as a total number per stream with no estimate of variation. Number of redds can also be described as multiple counts temporally and/or spatially (supports index area time series data). Spawning ground surveys are conducted beginning in August each year and occur in a predetermined order to coincide with the period just after the peak of spawning in each system (Keefe et al. 1994). Surveys are usually completed by the second week in September. Additional survey passes are conducted if spawning is not complete by the last scheduled pass. Usually, surveys are conducted by two people walking downstream in each section. Stream sections average 2-3 miles in length depending on accessibility. We count the number of redds (occupied and unoccupied), the number of live fish observed (on redds and off redds), and the number of carcasses. A survey section identification number is associated with carcasses and redd data to support distribution analyses. In streams that will be surveyed with multiple passes, the location of the redd is marked on shore along with it's number and status, so that the number of new redds can be determined with each additional survey.

All carcasses found are measured (fork length), sex is confirmed, and percent of eggs spawned is estimated for females. Any identifying marks or tags are noted, and scales/fin rays are removed from the key scale/fin ray area (Nicholas and Van Dyke 1982; Kiefer et al. 2002) to identify age. If any fin marks are observed, the snout of the fish is removed to be examined for the presence of a coded-wire tag. Once sampled, the tail is removed to prevent repeated sampling on future surveys and the carcass is placed back in the stream. In years with high abundance carcass sub-sampling will be implemented in a fashion to representatively quantify carcasses over space and time. Representative sub-sampling over space and time is logistically difficult and carcass abundance to date has not exceeded processing abilities.

1.a.3 - *Fish per redd ratio* is derived by dividing the point estimate of population size by the total number of redds observed above the weir. The purpose of the fish per redd calculation is to estimate adult escapement given a reasonable estimate of redds in a system. Variation may stem from pre-spawn mortality, errors in estimates of population size and errors in redd counts. The population size is estimated using a mark-recapture analysis of carcasses recovered above the weir from a known number of marked fish released above the weir (see 1.a.1). Application of the lower and upper 95% confidence intervals in a similar fashion as the point estimate is used to generate an annual fish per redd range. This method is used in the Imnaha River, Lostine River, Catherine Creek, and upper Grande Ronde River. In some years inadequate numbers of adults are released above weirs to generate a robust population estimate. In these years a tributary specific running average is applied where at least 5 years of data exists. Alternatively, a standard Grande Ronde river subbasin conversion factor will be applied as an average of robust fish per redd ratio for the entire subbasin when streams lack at least 5 years of robust fish per redd estimates.

It is important to differentiate between fish per redd and adults per redd. The main calculations concern adults per redd (where jacks are NOT included in population estimate). The reason jacks are not included is that they are either not recovered at the same rate as other males or females, or they were released in very small numbers, and so do not contribute to recoveries in a significant way. We do calculate the number of jacks that were not trapped and estimate the total number of fish spawning above the weir.

1.a.4 - *Spawner abundance* is defined as the number of adult (jacks excluded) present in a tributary contributing to spawning. This measure accounts for reductions in population size as described by adult abundance to each tributary resulting from harvest and prespawning mortality. As such this is a derived value. Spawner abundance can also be estimated by expanding redd counts from the estimated fish per redd.

1.a.5 – *Hatchery fraction* describes the percentage of the adult abundance to the tributary comprised of hatchery-origin returning adults. This performance measure should also be reported as hatchery fraction of the naturally spawning population described for age IV and V age classes (excluding jacks) as well as the full age class population (including jacks). Typically this performance measure is directly measured (with no description of variation) and based on carcass recovery composition from spawning ground surveys and direct weir captures. All hatchery-origin fish are marked either internally or externally (Appendix B). Adjustments for selective fish passage at weirs and selective in-tributary harvest (forms of artificially introduce bias) are required for description of hatchery natural composition to the tributary.

1.a.6 – Annual *age class structure* is characterized by the proportional distribution of ocean age returns in each return year. Methods for determining individual fish age vary by stream, fish origin and period of classification. Typical methods include; known age assignment via Coded Wire Tag (CWT), Passive Integrated Transponder (PIT) tags, and Visual Implant Elastomer

(VIE) tags; length frequency assignments, and scale/fin ray indices. Preliminary age assignments are inferred from length frequency analysis constructed for each stream. Validation of length frequency age assignments is based on known hatchery-origin fish age as identified by CWTs (all fish marked with CWTs). Validation of natural-origin fish age is based on an index of fish age from scale or fin ray age analysis. Sensitivity of P:P analysis to high variation in age class structure estimates is low (TRT- R. Carmichael Pers. Comm). A minimum sample size of 20 fish per stream is required annually, if sample size is smaller that 20 an average age class structure for that stream (preferred) or subbasin is applied.

Age-at-return describes the relative distribution of spawner age for a single brood year (cohort). This involves run-reconstruction for each brood year (cohort) production and is based on age class specific (ages III-VI) adult abundance estimates to the tributary over multiple years (1.a.1). The resulting adult abundance estimate by age for each cohort is expressed as a proportional distribution. Estimates can be influence by disproportional harvest over years. CWT tag harvest contribution assessment is used to correct for variable harvest rates.

1.a.7 – *Adult spawner sex ratio* is described as percentage of adult population (with and without jacks) comprised of females. This is determined by direct observations from weir captures and from carcass composition sampled during spawning ground surveys. Validity of weir data relies on collection efficiency of the weir and ability for accurate sex determination; both of which are tributary specific and vary annually. Estimates derived from carcass recoveries provide known sex classification, but are limited to non-jack age classes due to non-representative sampling of jacks. Sex ratio based on carcass recovery are also generally consider non-representative due to differential post-spawn behavior between males and females prior to death. Carcass sampling is described under 1.a.2 methods.

Annual female percentage will be characterized over time as an average for that stream. Annual observations will be tested for significance relative to the average. Results will be determined for each population as a whole and independently for both hatchery and natural origin components. A two-tailed t-test will be applied to examine differences between hatchery and natural percent females over 5 year intervals. Gross level of deviation from 1:1 ratio or from the average in a stream should raise concerns.

1.a.8 – *Prespawning mortality* is characterized as the percentage of female carcasses recovered during spawning ground surveys that are zero to 25% percent spawned. This percentage can be expanded to an estimated abundance of prespawn mortality by multiplying the percentage by the estimated adult escapement. This approach only captures prespawning mortality during the spawning period, as such it is a minimum estimate that does not represent total in-tributary mortality prior to spawning. Accurate determination of prespawn status of males is not possible due to sperm regeneration early in the spawning season.

Annual percentage of prespawning mortally will be characterized over time as an annual average for that stream. Annual observations will be tested for significance relative to a historical average. Trend over time will be examined with one-way ANOVA. Results will be determined for each population as a whole and independently for both hatchery and natural origin components. A two-tailed t-test will be applied to examine differences between hatchery and natural prespawn mortality rates over 5-year intervals.

1.a.9 – Quantification of *tributary harvest* is the primary performance measure under M&E objective 5b. A full description of harvest methods is provided there.

1.a.10 – *Progeny-per-parent* ratio is calculated from run reconstructions over time. Annual total escapement is determined by combining estimates of escapement upstream of weirs from 1.a.1, expanded escapement estimates downstream of weirs from 1.a.2, 1.a.3 and 1.a.8, and harvest from 1.a.9. Escapement is partitioned for hatchery and natural groups from 1.a.5 by age class structure (1.a.6) and gender (1.a.7). Partitioned abundance for all adult year class in a cohort will be summed and applied to the P:P ratio calculations as described in 1.a.

<u>Monitoring and Evaluation Objective 1b:</u> Determine and compare relative reproductive success of hatchery and naturally produced Chinook salmon.

Ho: Reproductive success of naturally spawning hatchery fish is equal to that of naturally produced fish.
Ha: Reproductive success of naturally spawning hatchery fish is significantly different than that of naturally produced fish.

Ho: Mate choice is random with respect to parentage of individual fish (i.e., wild, conventional and captive brood stock).
Ha: Mate choice with respect to parentage of individual fish is selective and is significantly different.

Ho: Selection gradients are the same in the hatchery and the wild and do not differ between sexes nor between hatchery- and naturally-produced fish.
Ha: Selection gradients are significantly different for hatchery and natural origin fish between sexes.

Ho: Interfamily variance in reproductive success is so great that it is not possible to make meaningful conclusions about specific selective factors and the quantitative genetic interactions between hatchery and wild components of these supplemented populations. Preliminary results indicate that although variance is large, effect sizes can also be large.
Ha: Interfamily variance can be accounted for relative to effect size.

The key performance measure here is the relative proportion of offspring produced per parent by origin. It is measured through DNA pedigree analysis and direct estimation of reproductive success as proposed by NOAA Fisheries and funded by BPA under project 198909600. Offspring are monitored as parr or smolts and as adult returns. Supporting performance measures include adult abundance to tributary, hatchery fraction, age-at-return, adult spawner sex ratio, fecundity (by age and size), and spawn-timing (by origin).

The reproductive success studies present the opportunity to test specific hypotheses regarding reproductive success, mate choice and concomitant rates of gene flow among hatchery and natural components of the test populations.

Performance should be monitored for at least two complete generations and replicated annually three to five year. Priority areas for implementation are the Lostine River and Catherine Creek with the examination of three production groups per stream (natural, captive broodstock, and conventional hatchery origin adults). Secondary areas for application included upper Grande Ronde and the Imnaha rivers (area upstream of the weir only).

Methods

1.b.1 - At selected weirs, all adults that can be captured will be sampled non-lethally for DNA-typing as they are passed up river (opercle punch tissue). Annual stratified samples of wild-caught parr will be collected from rearing areas above the weirs. All conventional hatchery broodstock fish will be sampled as well as their resulting progeny.

The development of highly polymorphic microsatellite loci presents a powerful alternative to simply measuring genetic change through time at a population level. It is now possible to establish the parent pair-offspring relationships among specific individuals in a semi-closed system (e.g., from a finite pool of parents that have been finclipped as they are passed over a weir). For the first time it is possible to obtain a direct, "real-time" estimate of relative reproductive success of specific fish spawning in the wild (Garant et al. 2001).

Opercle punch tissue will be taken from all Chinook adults passed over the weirs on the Lostine River and Catherine Creek (possibly in the Imnaha and upper Grande Ronde rivers as well). Resulting juveniles are sampled in rearing areas above the weir and assigned to specific matings based on comparison of multilocus microsatellite genotypes among candidate parents. This has been done by using both exclusionary criteria (finding a parent/mating that results in an exact match to a particular juvenile), and probabilistic approaches that explore the likelihood of each possible parentage assignment and establish statistical criteria for accepting the true parent (Marshall et al. 1998). Each year, samples of 250-500 juvenile fin clips will be taken from selected trap sites. Juveniles will be sampled as out-migrating smolts, and finally the cohort will be sampled one last time as returning adults. This research should be carried over at least two complete generations.

Assumptions: A large proportion of the adults spawning in the test systems (i.e., above the three weirs) will be captured and sampled. Clearly comprehensive sampling will not be achieved in all years, especially in the Lostine River and Catherine Creek systems. Preliminary results from Little Sheep Creek (steelhead) show that many parr seem to be the progeny of resident parents (not sampled at weirs). Nevertheless, some powerful insights have been obtained from only partial sampling of potential parents. Simulations show that statistical power declines substantially when less than 50% of the parents are sampled (M. Ford pers. comm.), yet, in practical application, this loss of power may be made up by sampling more offspring or more loci.

<u>Monitoring and Evaluation Objective 1c:</u> Determine and compare the spawning distribution of hatchery and natural origin Chinook salmon in Imnaha, Lostine, upper Grande Ronde rivers and Catherine Creek.

Ho: There is no difference in distribution of female carcasses by origin between hatchery fish and naturally produced fish spatially in each stream.
Ha: There is a significant difference in distribution of female carcasses by origin between hatchery fish and naturally produced fish spatially in each stream.

Ho: Hatchery-origin females are distributed randomly over the available spawning habitat.
Ha: Hatchery-origin female are not distributed randomly over the available spawning habitat.

Ho: The distribution of hatchery-origin females is concentrated around release site.
Ha: The distribution of hatchery-origin females is not concentrated around release site.

The key performance measure is *adult spawner spatial distribution* of female carcasses. Spatial distribution is directly characterized as a proportion of female carcasses (of each origin) by sampling reach expressed to the total carcasses recovered (of the same origin) in that population. The distribution of hatchery-origin fish may be clumped around the release sites (Slaney et al. 1993). Description of the range of natural and hatchery spawner distribution will also be provided under this objective as indicated by the lower and upper survey reaches where natural and hatchery female carcasses are observed annually.

In order to do this hypothesis testing, a goodness-of-fit test such as Kolmogrovov-Smirnov (K-S) test (Steel et al. 1997), or a log-linear model is appropriate for testing data from a single year. When testing with data of multiple years where years are replicates, two-factor ANOVA is an efficient method where factors are fish type (hatchery fish vs. naturally produced fish), and reach (reach 1, reach 2, …). Time (year) plays a role of 'pair.' This is a within stream comparison only.

The data set is hatchery-origin female carcass frequency by reach, and a goodness-of-fit test such as χ^2 is appropriate. In the χ^2 test, we can calculate the expected frequency of carcass in each reach by applying the equal portion (uniform) of the total carcass sample size to each reach. Because biologists often find that carcass distribution is concentrated around a release site, the above null hypothesis is likely to be rejected. If the above null hypothesis is rejected, we would need to test further whether the distribution is concentrated around a release site or not. We assume that the closer a reach is to release site, the more carcasses it will have. That is, assuming that the number of carcasses by reach linearly increases from the farthest reach to the closest reach, we calculate the expected frequency of carcasses in each reach.

We will test at 5% Type I error (i.e. $\alpha = 0.05$), and show p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

Monitoring of adult spawner spatial distribution is a long-term monitoring process, which should continue for at least three generations under consistent operation protocols (longer with program modifications). If hatchery-origin spawner distribution mimics natural-origin spawners at end of three generation then monitoring of this objective could be discontinued. Assessment of the this M&E objective will occur in all treatment streams; Imnaha River, Lostine River, Catherine Creek, and the upper Grande Ronde River.

Methods

1.c.1 – If hatchery fish are to help fill vacant habitat for natural production, spawning should be dispersed throughout the available spawning habitat within the treatment stream. However, co-managers desire the distribution to be limited to the stream of origin. Reaches where fish choose to spawn may be related to time of spawning, temperature, substrate size, etc. with later maturing fish tending to spawn further downstream. If spawning is not well dispersed possible causes will be investigated. These will include release method and location, weir impact, stream temperatures at time of spawning, and spawning gravel abundance and location.

Carcass recovery methods are described in section 1.a.2. Analysis requires the assumption of equally sampling effort and probability of carcasses detection over space, time, and origin. We feel this is a reasonable assumption given that spawning ground surveys are generally conducted over the entire potential spawning area on a single day and repeated three to four times spanning the entire spawning period. Probabilistic sampling could be alternatively applied, however the entire spawning area is already being comprehensively surveyed for other performance measures (index of spawner abundance).

Monitoring and Evaluation Objective 1d: Determine the effects of hatchery supplementation on the abundance and productivity of Imnaha, Lostine, upper Grande Ronde rivers and Catherine Creek spring Chinook salmon populations.

Ho: There is no difference in the progeny-per-parent ratio of naturally produced fish in supplemented populations and unsupplemented populations over time for each stream.
Ha: There is a significant difference in progeny-per-parent ratio between supplemented and un-supplemented populations over time for each stream.

Ho: There is no difference in the smolts-per-redd ratio of naturally produced fish in supplemented populations and unsupplemented populations over time for each stream.
Ha: There is a significant difference in smolts-per-redd ratio between supplemented and un-supplemented populations over time for each stream.

Ho: There is no difference in the adult-per-redd ratio of naturally produced fish in supplemented populations and unsupplemented populations over time for each stream.
Ha: There is a significant difference in adult-per-redd ratio between supplemented and un-supplemented populations over time for each stream.

Ho: There is no difference in population viability between pre-supplementation and post-supplementation.
Ha: There is a significant difference in population viability between pre-supplementation and post-supplementation.

Three key (derived) performance measures are used to index population productivity; progeny-per-parent ratio, smolts (offspring) per redd, and adult per redd. We are evaluating any change in these measures for the natural production component within supplemented populations. Associated performance measures include those described in 1a, in addition to juvenile emigrant abundance, smolt equivalents, and juvenile survival to Lower Granite Dam. Juvenile Chinook salmon emigrate from natal streams as parr, presmolts, and smolts (both yearling and precocial yearlings). The relative abundance of emigration at each life is variable within and between streams and is likely influenced by environmental conditions and juvenile abundance. Fish will be marked with PIT tags for subsequent survival estimation.

Natural population productivity is assessed using 1) relative change of productivity within that population from base-line levels (pre supplementation activities), and 2) relative consistency in productivity measures between supplemented and reference streams over time (pair-wise comparisons). We can use the reference populations and the residual of the measured P:P and the stock recruitment generated value. We can adjust P:P based on SAR's to factor out the influence of emigration survival and ocean conditions. We can also look at parr and smolt produced per parent, or per redd, and compare to pre-supplementation estimates. We will apply two modeling approaches; Stock Recruit Modeling and Diffusion Approximation Model.

Stock Recruit Modeling - We will compare progeny-to-parent productivity and stock-recruitment relationships for three Grande Ronde supplemental populations with reference values. For each of the supplemented populations and the two reference populations in the Grande Ronde basin we have a time series of pre-treatment progeny-to-parent ratios and have developed stock-recruitment relationships. We have a data series that extends from broodyears 1972-1997, omitting the broodyears from 1986-1993 due to high abundance of hatchery fish in both treatment and reference populations. We have pre-1972 data sets, but omit them from the pre-treatment time period because of major survival and productivity changes that occurred since the last lower Snake River dam (Lower Granite Dam) became operational. Annual estimates of progeny-per-parent in the post-treatment time period will be compared with two benchmarks. First, we will compare P:P with an expected value derived from the pre-treatment stock-recruitment relationship. Second, we will establish a pre-treatment relationship between each reference population and each treatment population. This relationship will serve as the reference value to compare the post-treatment relationship. In addition, following a minimum of ten broodyears of treatment we will compare the pre- and post-treatment stock-recruitment relationships within populations. Methods used for post-treatment progeny-per-parent determination were previously described. Methods used to develop pre-treatment progeny-per-parent and for stock-recruitment relationships are described below. A similar approach for post-treatment stock-recruitment relationship development will be used with the component estimates (abundance, age-structure, etc.) derived as previously described in objective 1a.

Diffusion Approximation Model. We apply data of time series abundance to the Diffusion Approximation Model (also called a Wiener-Drift process model) to evaluate population viability. The DA model has been recommended for use when analyzing time series data regarding abundance (Dennis et al. 1991, Holmes 2001, Holmes and Fagan 2002). The advantages of the DA model over an ordinary regression model can be summarized as follows (Hyun and Talbot 2004): (1) autocorrelation in population sizes over time does not exist (2) The DA model is a mechanistic model not an empirical model, (3) the response variable values are independent, and normally distributed, and (4) the normality assumption is valid even for small observations.

The DA model is based on a stochastic exponential growth model. A standard form of the stochastic exponential growth model is as follows: = $_t$*N* $_0$exp( ) $_t$*Nt* µå ··+, where $_t$å ~. is the population size at time t, µ is the slope of the population trend overtime, and$_2$(0,) *N* ó ·$_{tt}$*N* å is time-dependent error term. $_t$å is assumed to follow a Gaussian distribution where its mean and variance are zero and '$_2$ó *t* ·'. Thus, the stochastic exponential growth model has two parameters: µ and $_2$ó. µ is the slope of the abundance trend, and $_2$ó represents the variation of it. However, it is discouraged to directly apply the stochastic exponential growth model to time series data because the model's time step is discrete and its population state is auto-correlated. As a result, estimates of two parameters in the model become inaccurate.

The approximate normal distribution of log (*N*t) is identical to the distribution of a Wiener process with drift (Goel and Richter-Dyn 1974, Ricciardi 1977, Karlin and Taylor 1981). The Wiener-drift model is a simple type of continuous-time, continuous-state, Markov stochastic process known as a diffusion process. The DA model has the property that log (is distributed normally with mean)$_0$/ $_t$*N N t* µ and variance$_2$*t* ó (Dennis et al 1991). Two parameters of µ and$_2$ó determine various well-known risk metrics to a population (Dennis et al. 1991). In other words, those risk metrics are functions of µ and $_2$ó. Well-known risk metrics include population growth rate, extinction probability, probability that the recent population size declines by a certain proportion, and time to extinction, etc.

As a risk metric in which pre-supplementation and post-supplementation are compared, we choose the population growth rate of a long term called "ë". Without a theoretical study, some people use various variables to calculate ë . Those variables include logarithm of recruits per spawner, geometric means of natural cohort return rate for some year interval (say, 8 year interval), smolt-to-adult ratios, simple regression of log natural abundance against time, and residuals from a stock-recruit relationship, etc. The estimate of ë from the use of logarithm of recruits per spawner can be different from that calculated with µ and $_2$ó from the DA model for a short data series, but theory on stochastic population processes says they are equal eventually for a long term data (Caswell 2001). Also estimates of ë from the use of other variables do not cover the entire life cycle (Holmes 2003). The estimate of ë must be a measure of the integration of survivorship and fecundity over the entire life cycle rather than that of one stage's survivorship or fecundity alone. It is efficient to use time series data of adult abundance rather than to use data from diverse variables. When calculated from two parameters in the DA model where time series data of adult abundance are used, the estimate of ë is robust. We will calculate ë for the population of each treatment stream with data from two separate periods : pre- and post- supplementation . As a result, we will have two estimates for ë for each population of the treatment streams (ë$_{s,pre}$ and ë$_{s,post}$ for population of treatment streams).

However, we are concerned about environmental variability over time and its non-constant nature. Therefore, we need to remove the effect of temporal variability on the estimate of ë . We will calculate ë for reference (control) stream populations during the respective pre- and post- supplementation periods. (ë$_{cont,pre}$ and ë$_{cont,post}$, where ‘cont’ denotes populations of reference streams). We may use data from lumped reference populations or use mean values of ë estimates from each reference population. For ë of treatment populations *relative to* that of reference populations, we will use the difference between those two values: i.e. (ë$_{s,pre}$ - ë$_{cont,pre}$) and (ë$_{s,post}$ - ë$_{cont,post}$). We can calculate these values for populations of all treatment streams. Treatment population plays a role of ‘pair.’ Data set for hypothesis testing can be organized in a table where columns are pre-supplementation and post-supplementation, rows are treatment populations, cells under the pre-supplementation column have (ë$_{s,pre}$ - ë$_{cont,pre}$) for each treatment population, and cells under the post-supplementation column have (ë$_{s,post}$ - ë$_{cont,post}$) for each treatment population. The paired t-test is appropriate to compare pre-supplementation and post-supplementation, where ‘pair’ is treatment population. We will test at 5% Type I error (i.e. á = 0.05), and show p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

The data sets supporting this analysis are long-term, requiring P:P ratios over a minimum of three (preferably five) generations (25 years). Performance measure monitoring will be required in the three pre/ post supplementation treatment streams (Lostine River, Catherine Creek, and Upper Grande Ronde), the Imnaha River, and the full suite of reference streams (Wenaha River, Minam River, Secesh River, Marsh Creek, Snake Basin aggregate).

Methods

1.d.1 *–Progeny-per-parent ratio* for natural production in treatment streams will be provided as described in 1a. P:P ratio for reference streams follows the basic methods describe in 1a with exception that estimation of adult spawner abundance to tributary is not conducted via mark recapture assessment due to lack of weirs on reference streams. Adult abundance estimates in reference streams relies on expansion of extensive area redd counts.

1.d.2 - Abundance of parents (spawners) is estimated for each year where peak redd counts are available in index spawning ground areas. The index area peak redd counts are expanded to account for spawning in other areas outside index surveys. Spawner abundance is the product of redd counts and an estimated number of fish per redd. The number of natural-origin spawners is estimated by applying the rate that non-hatchery-origin carcasses are observed among all carcasses recovered during spawning ground surveys to the total spawner abundance estimate. The total return to the population unit is the sum of spawners on the spawning grounds, an estimated number of fish that perish before spawning (pre-spawning mortality), fish removed in in-basin fisheries, and any fish removed for broodstock purposes. To estimate the total return to the mouth of the Columbia River, the run to the Grande Ronde basin is expanded to account for the rate at which upriver spring Chinook salmon are removed in mainstem Columbia River fisheries and the rate of adult passage losses through the Columbia and Snake River main stem dams and impoundments (“conversion rate” or “interdam losses”).

1.d.3 - Recruitment (progeny abundance) to the spawning grounds is estimated by apportioning the spawner abundance estimate for each return year into cohorts. Age is determined from scale analysis. Recruitment estimates do not include fish of known hatchery origin. These estimates do include adult in-basin pre-spawning mortalities, tributary removals for broodstock or fisheries, removals in Columbia main stem fisheries, and losses during upstream passage past

Columbia and Snake River dams and impoundments. Estimates of adult recruitment to the Columbia River mouth do not include potential impacts from ocean fisheries. Ocean harvest impacts are considered to be near zero (Beamesderfer et al. 1997 and Marmorek and Peters 1998). We are presently in the process of using smolt-to-adult survival rates in the stock-recruit analysis to determine if we can improve relationship by reducing variability.

1.d.4 - Spawning population: Redd counts are compiled for this run reconstruction into two categories as available and defined as:

> Historical Index: spawning ground surveys conducted in the same stream reach at the same time of year on an annual basis.
>
> Historical Extensive: spawning ground surveys conducted at the same time of year as historical index surveys in areas outside of the historical index areas. Extensive surveys have been conducted annually since 1986.
>
> For the historical extensive survey reach during years when it was not surveyed, an assumed redd count is calculated by multiplying the known index redd count by the average relationship between extensive survey redds and the sum of extensive and index redds.

The annual estimates of redds for the historical extensive index reaches are summed and then multiplied by a fish per redd estimate (3.2) to estimate annual minimum abundance of spawning fish. The fish per redd estimate is that used in Beamesderfer et al. (1997) based on relations between weir counts and redd counts in Lookingglass Creek and the Imnaha River (Beamesderfer et al. 1997).

1.d.5 - Proportion of hatchery-origin spawners: The proportion of hatchery-origin spawners is estimated using a combination of scale analysis and coded wire tag recoveries. Past hatchery fraction estimates are documented in ODFW, La Grande Research files (Keniry 2002). Hatchery origin fish are assumed not to be present on the spawning grounds prior to 1986 because LSRCP produced hatchery fish did not return to the basin until 1986. Run reconstruction analysis does not consider reproductive rates for hatchery-origin spring Chinook salmon that spawn naturally.

1.d.6 - Pre-spawning survival: An assumed constant pre-spawning survival rate of 0.90 is used to account for adult recruits that die in the basin prior to spawning. The assumed rate is that used in Beamesderfer et al. (1997). However, hatchery or wild origin adults that are trapped and outplanted, or trapped, removed, held, and then returned could experience a higher pre-spawning mortality rate. The Beamesderfer et al. (1997) estimate is conservative compared to observations of incompletely spawned females (partial or complete egg retention observed in carcasses) from Snake River tributary surveys conducted from 1953 through recent years (Marmorek and Peters, 1998) and from recent John Day Basin surveys (Wilson et al. 2001).

1.d.7 -Tributary harvest: Sport harvest is estimated from voluntary returns of anglers' "punch card" records for the years when a sport fishery was open in the Wallowa River during this run reconstruction period. Monthly salmon catch estimates for the months of April through August are summed and then adjusted with a "non-response bias factor" (ODFW unpublished information). An average of harvest rates during open seasons is assumed prior to 1956, when no punch card information was available. Treaty Indian harvest is assumed to equal sport harvest (personal communication, R. Carmichael, ODFW, as cited in Beamesderfer et al. 1997). In-basin harvest rates are conservative estimates because limited catches in the Grande Ronde River are not included (Beamesderfer et al. 1997).

1.d.8 - Columbia mainstem passage rates: Progeny of parents include fish unaccounted for through escapements to tributaries downstream of the confluence of the Grande Ronde and Snake rivers and in removals in Columbia main stem fisheries.

1.d.9 - Mainstem Columbia River harvest: Progeny of parents include fish removed in Treaty Indian fisheries upstream of Bonneville Dam, sport fisheries, and commercial fisheries downstream of Bonneville Dam.

1.d.10 - Age at return: Generally, age composition of adults on the spawning grounds is determined from analysis of scales collected from carcasses sampled during spawning ground surveys. For years when 20 or more readable scale samples were available in individual spawning areas, time- and spawning area-specific proportion at age is used. For years when less than 20 readable scale samples were available in individual spawning areas, but 20 or more readable scale samples were available for all Grande Ronde Basin spawning areas combined, time-specific proportion at age is used. For years when less than 20 readable scale samples were available for the Grande Ronde aggregate, an average of spawning area-specific proportion at age over time was used (except in 1995, when the sample size was 19).

1.d.11 - Redd counts in their truest sense are an index of adult abundance. However, in many cases this index is expanded to estimate actual spawner abundance. The quantification of redds includes many possible sources of error including inter-observer variation (precision) and identification of "true" redds (accuracy). Additional uncertainty is associated with expansion factors used to expand redd counts into spawner abundance or tributary escapement estimates (i.e. fish per redd, sex ratio, prespawning mortality, age class structure).

A small-scale study to quantify the accuracy and precision of redd counts in three key populations (Secesh River, Imnaha River, and Lostine River) will be accomplished through replicated reach counts by a single and multiple observers; comparison of known escapement numbers to expanded redd counts (both raw and adjusted for sex composition, age structure, and prespawning mortality), examination of the variation in fish per redd, sex composition, age structure, and prespawning mortality across streams.

1.d.12 - In addition to the redd count expansion methods in reference streams we will quantify adult escapement via remote sensory methods in the Secesh River and the Minam River. Acoustic imaging is currently being applied and validated in the Secesh River. Acoustic imaging will be used in the Minam River system (assuming valid results of methodology are demonstrated in Secesh River) to provide a direct measure of adult escapement. Results will be used to test accuracy and precision of redd count expansion approaches for adult abundance performance measures. Application in all reference streams will be examined after completion of the Minam River small-scale study.

Acoustic imaging is a new class of identification sonar, which gives near video quality images for inspection and identification of objects underwater. This new technology is called DIDSON, (Dual frequency IDentification SONar). DIDSON sets a new standard for imaging sonars and high-definition sonars. It can be a surrogate for optical systems in turbid water. DIDSON operates at two frequencies (1.8 MHz and 1.0 MHz) and uses acoustic lenses, which allow sharp images from 1 m to over 30 m in range with enough information to show the size, shape and movement of an object. The observer actually views a two dimension silhouette of a fish swimming either upstream or downstream (http://www.apl.washington.edu/programs/DIDSON/DIDSON.html).

The sonar unit is small and requires only 30 watts of power. High frequencies are used for better image resolution at short ranges (1 to 12 M). Lower frequencies are being tested for fish detectability at ranges of 60 M and greater.

The advantages of the DIDSON sonar unit are: 1) it uses a higher frequency resulting in better target resolution, 2) dual frequencies provide a more presentable and understandable target image, 3) has a larger signal beam of 12°x30°, instead of 2°x8°, that allows the target to be tracked over a greater distance, 4) does not require extensive aiming and testing, 5) ease of operation and software data analysis, 6) does not require extensive manipulation of the substrate for proper alignment, 7) requires only one minor substrate manipulation), 8) can be relocated easily.

Estimates of precision and accuracy in other environments indicates census counts with 98-100% precision Annual validation of acoustic image results will be supported with underwater video observations. Intensity and duration of validation efforts will be site specific. Similar to adult escapement assessed via mark-recapture methods, spawning ground surveys will provide age class structure, adult spawner sex ratio, and hatchery fractions in streams monitored with acoustic imaging.

1.d.13 - *Juvenile emigrant abundance* is estimated by two methods; 1) as the abundance of juvenile emigrants by life stage leaving the tributary and 2) abundance of smolt (equivalents) reaching Lower Granite Dam from a specific tributary. Estimation of the abundance of juvenile emigrating by life stage is achieved via representative trapping actively moving juveniles past designated points near tributary mouths.

For the purpose of this monitoring, we assume that all juvenile spring Chinook salmon captured in traps are downstream “migrants”. The term “migratory year” (MY) refers to the earliest calendar year juveniles are expected to migrate to the ocean. The term “brood year” (BY) refers to the calendar year eggs were fertilized. Life stages based on age, biological development, and arbitrary seasonal trapping dates. Spring/summer Chinook salmon “young of the year (YOY)” are newly emerged fish that are captured prior to July 1 (spring trapping season). Spring/summer Chinook salmon “parr” are fish entering their first summer in fresh water that are collected between July 1 and August 31 (summer trapping season) as they emigrate from natal streams. Although spring/summer Chinook salmon parr in the act of emigration before September 1 are defined as parr, they also may be considered presmolts. Spring/summer Chinook salmon “presmolts” are actively emigrating juvenile fish greater than one year of age but less than eighteen months of age between September 1 and December 31 (fall trapping season). Presmolts in the act of emigration do not show typical smolt characteristics (e.g., silvery color and the tendency to easily lose their scales). Spring/summer Chinook salmon “smolts” are actively emigrating juvenile fish greater than one year old captured between January 1 and June 30.

Spring/summer Chinook salmon "yearlings" are in their second summer or fall, or third spring. Spring/summer Chinook salmon "precocial yearlings" are yearlings that release milt when handled. Type 1 yearlings are those that leave the natal stream shortly after emergence and rear in downstream locations. Type 2 yearlings are those that rear in the natal stream a second summer. For analysis purposes, we arbitrarily define trapping seasons as follows: 1) spring season - trap installation through June 30; 2) summer trapping season - July 1 through August 31 and; 3) fall trapping season - September 1 through trap removal.

The abundance of juvenile spring Chinook salmon emigrating from the Imnaha River, Lostine River, Minam River, Wenaha River, Catherine Creek , upper Grande Ronde River, Secesh River, and Marsh Creek are determined by operating rotary screw traps throughout the migratory year. Although we attempt to fish the traps continuously through the year, there are times when a trap cannot be operated due to low flow or freezing conditions. There are also instances when traps are not operating due to excessive debris or mechanical breakdowns. We do not attempt to adjust population estimates for periods when traps are not operating. For this reason, our estimates represent a minimum number of migrants. Our definition of a "trap day" consists of two periods from 1800 hours to 0600 hours and from 0600 hours until 1800 hours. Our observations of fish movement suggest that there is a strong diurnal pattern to migration, with the majority of fish migrating between 2200 and 0400 hours. High water and debris cause the screw traps to be inoperable for short durations in the spring and early summer seasons. When a trap can only be operated between 1800 to 0600 hours we use the term "half day," and those data are included in analyses. However, if a trap is inoperable from 1800 to 0600 hours, we assume that the bulk of the daily migration has been missed. When a trap day is missed, we interpolate migration for that day by averaging migration estimates from the previous and subsequent day.

The rotary screw traps are equipped with live boxes that safely hold hundreds of juvenile spring Chinook salmon trapped over 24–72 h periods. All juvenile spring Chinook salmon captured in traps are removed for enumeration and interrogated for PIT tags. We attempt to measure fork lengths (mm) and weights (g) of at least 100 juvenile spring Chinook salmon each week. Prior to sampling, juvenile spring Chinook salmon are anesthetized with MS-222 (40–60 mg/L). Fish are allowed to recover fully from anesthesia before release into the river. River height is recorded daily from permanent staff gauges. Water temperatures are recorded daily at each trap location using thermographs.

Migrant abundance is estimated by conducting weekly trap efficiency tests throughout the migratory year at each trap site. A sub-sample of fish is marked with PIT-tags for trap efficiencies and survival studies, and other subsamples may be marked with caudal fin clips or Bismark-Brown dye for trap efficiency estimates. Fish must be greater than 59 mm to be PIT-tagged or greater than 39 mm to be fin clipped or dyed. Each season, a separate group of yearlings are PIT-tagged for evaluation as precocial or non-precocial yearlings. PIT-tag protocols follow procedures described by Kiefer and Forster (1991) and the PIT Tag Steering Committee. Tag needles and PIT-tags are sterilized in a 70% ethanol solution for ten minutes prior to use and between uses. After marking, fish are held in the stream in live boxes. Live boxes are large plastic shipping boxes with lids and numerous holes drilled into the sides or ends of the boxes. Fish are released after 12 hours, usually at dusk, when they appear to be totally recovered from the anesthetic. To provide trap efficiency evaluation data, a sub-sample of marked fish is released approximately 0.4 km upstream of the trap or at least two riffles and a pool upstream of the trap. All other fish are held in separate live boxes and released below hydraulic controls downstream of the trap. Trap efficiency is determined by releasing a known number of paint-marked or PIT-tagged fish above each trap and enumerating recaptures. Up to 300 juvenile spring Chinook salmon are marked and released each week. On days when a trap stops operating, the number of recaptured fish and the number of marked fish released the previous day are subtracted from the weekly totals.

To calculate seasonal and brood year specific migration estimates from rotary screw trap operations we utilize a Gauss program developed by the University of Idaho (Steinhorst 2000). Gauss (Aptech Systems, Maple Valley, Washington) is a structured programming language where the basic variables are matrices rather than scalars. We divide the trap seasons into periods, typically 7 to 10 days in length. The length of periods is selected to minimize environmental variation within each period, which presumably translates to a relative decrease in variation of trap efficiencies within a given period. Fish are marked and released upstream of the trap. The recaptured portion of the marked fish provides an initial calculated p_1 and the number of unmarked fish provides an initial N. This information is inserted into the Gauss program which iteratively maximizes the log likelihood, $\ln L(N,p_1)$ until the estimate does not change significantly (stabilization). Since the estimators do not have a finite expectation, the Bailey (1951) modified estimator ($N^B_{simple\ h} = c_h$ X $(m_h+1)/(r_h+1)$ is used to determine N (Steinhorst 2000). The maximum likelihood estimates of N and the corresponding confidence intervals require minimal assumptions: 1) fish are captured independently with probability p and 2) marked fish thoroughly mix with unmarked emigrating fish. Our release sites are selected to maximize the probability that marked fish will mix with the general population prior to arriving at the trap.

Reported seasonal trap efficiencies are weighted efficiencies. The season is divided into the same periods as used for migration estimates. The trap efficiency is calculated for each period based upon marks released and marks recaptured. Using the periodic trap efficiency, the migration estimate is calculated for each period. The migration estimates for each period are summed for the season and that sum is divided into the total number of unmarked fish captured during the season.

Young-of-the-year (YOY) Chinook salmon fry are not included in smolt estimates for the spring season but are included in the summer parr estimate. Yearling or precocial Chinook salmon caught in traps during summer, fall, or spring are likewise not included in parr, pre-smolt, or smolt migrant estimates for the brood year being studied.

1.d.14 - *Juvenile survival to Lower Granite Dam and Smolt equivalents* - Description of juvenile emigrant abundance estimate at the tributary mouth using a standard term is useful given the prolonged emigration periods, differential emigration patterns across years and streams, and open population (mortality) characteristics over the assessment period. Total emigrants by life stage can be adjusted by differential survival rates to Lower Granite.

Through juvenile emigrant trapping we can estimate the proportion of the total population comprised of each juvenile life stage (parr, presmolt, smolt) leaving the natal stream. A significant portion of emigrants can be parr and pre-smolts creating uncertainty in the number of fish (smolts) produced from each life history strategy surviving to Lower Granite Dam (LGD), and because of this we have to estimate the number of fish surviving to (LGD). Using a passive integrated transponder (PIT) marking program we can estimate how many fish of each life stage survives to LGD. With those estimates we can calculate a smolt equivalent (for all life stages) that survived to LGD and this smolt equivalent number is the critical number used in smolt to adult calculations from LGD to LGD.

PIT tag technology allows fish to be individually marked and subsequently observed without being sacrificed. First-time detections of PIT-tagged fish at Snake and Columbia River dams are used to estimate migration timing and index survival for each tag group. There are three tag groups for which we estimate migration timing and index survival to Lower Granite Dam: the parr (summer) tag group, the presmolts (fall) tag group (early migrants, overwintering downstream), and smolts (spring) tag group (late migrants, overwintering upstream). There is very little downstream migration past our traps during December and January, although a few juvenile spring Chinook salmon are caught. Annual minimum tagging goals are established for each stream independently given the variability in survival rates and detection probabilities between streams. The "Sample Size Program" contained in the SURPH.2 model (Lady et al. 2001) is used to estimate minimum samples sizes per life stage. Typically a minimum of 500 to 1,500 fish are needed per life stage to obtain survival point estimates to Lower Granite Dam with 95% CI of 2.5%. In order to disperse PIT tags throughout each trapping period, we set daily PIT tag goals by dividing seasonal PIT tag lots by the number of trapping days in each trap season. When daily (or seasonal) PIT tag goals cannot be met, excess tags are deployed in subsequent days or seasons.

For each tag group we calculate two different indices of survival to Lower Granite Dam. These are dam detection rates and Cormack-Jolly-Seber (CJS) survival probabilities. We calculate detection rates for each tag group by dividing the number of first-time PIT-tag detections at all dams by the number of PIT-tagged fish released in each tag group. These detection rates are not adjusted to compensate for fish that may pass through the hydrosystem without being detected. Therefore, the detection rates are relative and represent the minimum rate for each tag group. We also use the CJS method in the SURPH 2.1 program to calculate the probability of survival to Lower Granite Dam for fish in each tag group (Lady et al. 2001). This method takes into account the probability of detection when calculating the probability of survival (detection probability = capture probability × survival probability). We use SURPH2.1 information to compare performances among and between the different life stages of tagged juvenile salmon. Both detection rates and CJS survival probabilities are reported to allow comparison to previous years' detection rate data.

1.d.15 – Smolts per redd describe productivity as the quantity of juvenile fish resulting from an average redd. Several forms of smolt equivalents could be applied here. We will utilize two measures: 1) smolts equivalents at the tributary mouth, and 2) smolt equivalents at Lower Granite Dam. In each case the smolt equivalent number does have associated variance, however the redd estimate does not. Confidence intervals can be established with application of the lower and upper bound smolt equivalent estimates to the redd estimate.

1.d.16 – The most restrictive performance measure associated with productivity being assessed here is characterized as the escapement estimate divided by the number of redds, thus providing an adult–per-redd ratio. This measure can be heavily influence by environmental factors and demographic characteristics of the population (abundance, age class structure and sex ratio). Even with these co-variables, it should be used as an initial indicator of productivity change.

<u>Monitoring and Evaluation Objective 1e:</u> Determine and compare life-stage specific survival rates for hatchery and natural fish in the Imnaha, Lostine, Upper Grande Ronde rivers and Catherine Creek.

Ho: There is no difference in survival rate of smolts from the tributary to Lower Granite Dam between hatchery produced fish and naturally produced fish over time for each stream.
Ha: There is a significant difference in survival rate of smolts from the tributary to Lower Granite Dam between hatchery produced fish and naturally produced fish over time for each stream.

Ho: There is no difference in smolt-to-adult return rate between hatchery fish and naturally produced fish over time for each stream.
Ha: There is a significant difference in smolt-to-adult return rate between hatchery fish and naturally produced fish over time for each stream.

Descriptive: Base line monitoring of life stage specific survival for trends over time.

Two primary performance measures describing life stage specific survival rates are examined; *juvenile emigrant survival to Lower Granite Dam* and *smolt-to-adult return rate (SAR)* for natural-origin fish and hatchery produced fish within each tributary. Characterization of juvenile survival of natural fish is limited to fish emigrating from tributaries as smolts for this objective to be comparable to hatchery fish released as smolts. Mark-recapture methodology utilizing Passive Integrated Transponder (PIT) tags and subsequent detections at mainstem dams generate survival estimates. Hatchery-origin fish be PIT tagged prior to release (see marking section). Natural-origin fish will be PIT tagged at time of emigration. Juveniles will be tagged representatively across the emigration period. Juvenile survival comparison will be determined with only emigrating natural smolts while SAR's quantification requires tags to be applied across all life history types. Smolt-to-adult return rates will be generated for four performance areas; tributary to tributary, tributary to Lower Granite Dam (LGD), LGD to LGD, and LGD to tributary. Coded Wire Tags (CWT) and PIT tag methods will be used to generate hatchery SARs. PIT tag methods will be utilized for natural origin group SARs. Associated performance measures include post-release survival (Imnaha hatchery production only), smolt-equivalents, and harvest.

Testing of results for significant differences in survival rates between hatchery and natural production within streams/subbasin annually and over five year periods. Juvenile survival estimates generated by the SURPH.2 model include a point estimate and associated variance. SAR estimates will be point estimates with no associated variance descriptor. When we compare two samples by year, the paired t-test is appropriate.

A χ^2 contingency table analysis is performed to test the null hypothesis that detection rates are the same for all populations (Zar 1984, equation 6.1). If detection rates differ, a Tukey-type multiple comparison on transformed proportions is used to determine which populations differ (Zar 1984, equation 22.13). Survival probabilities are compared between populations using the modeling and hypothesis testing capabilities of SURPH 2.1. Candidate models are compared by the likelihood ratio test, and Akaike's information Criterion (AIC).

We will test at 5% Type I error (i.e. $\alpha = 0.05$), and show p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

Assessment of juvenile survival rates will occur in the Imnaha River, Lostine River, Catherine Creek, Upper Grande Ronde River, and Grande Ronde River subbasin. Assessment of SAR for hatchery production will occur in the Imnaha River, Lostine River, Catherine Creek, and the Upper Grande Ronde River. SARs for naturally produced fish will be quantified at the subbasin scale, with the Imnaha Rive subbasin as a priority.

Methods

1.e.1. – *Post-release survival* of hatchery spring Chinook salmon from the Imnaha Satellite Facility (Gumboot) to the mouth of the Imnaha River is used as a component of relative fitness for the natural environment. This performance measure can be linked with juvenile survival estimates to Lower Granite Dam to partition mortality under natural conditions (Imnaha River habitat) and flow managed areas (Snake River – Lower Granite Reservoir). This measure is also used to provide a common reach for comparison of Imnaha River hatchery and natural juvenile survival to Lower Granite Dam estimates.

Post release survival probability is estimated by the Cormack, Jolly and Seber methodology (Smith et al. 1994) with the SURPH 2.1 model (Lady et al. 2001). The Imnaha rotary screw trap is located at rkm 7 and is designated as an integration site. The 95% confidence intervals (C.I.) are approximated from the standard error (SE) calculated by SURPH as follows: 95% C.I. = S ± (1.96(SE)), where S is the survival estimate for the reach. Hatchery Chinook salmon released from the acclimation facility are treated as a single group.

1.e.2. - *Juvenile survival to Lower Granite Dam:* Sample size requirements for determining survival to Lower Granite and McNary dams are estimated using the SURPH SAMPLE-SIZE program. Using observed survival and detection probability rates from recent hatchery releases, estimated minimum release groups of 1,000 (Lower Granite Dam) to 8,000 (McNary Dam) PIT tagged smolts are required for each treatment group for determining migration timing, median arrival dates and survival through the hydrosystem.

1.e.3 - Hatchery-origin smolt to adult survival rates are generated from coded wire tag recoveries. Coded wire tags are widely used by fisheries agencies as a major information collection tool. They assist in the collection of information for hatchery contribution studies, differential treatment studies, fishery contribution studies, and a variety of other related studies important for fisheries management and research.

Other types of marks will be used to distinguish hatchery-origin spring Chinook salmon. All hatchery-origin fish will receive at least one mark during juvenile rearing. Most fish of each brood year will receive a coded wire tag (CWT) in the snout and an adipose fin clip at Lookingglass Hatchery. Some fish may receive just a CWT or adipose clip without a secondary mark. All conventional broodstock progeny from each stream will receive a visual implant elastomer (VIE) tag in the adipose tissue behind one eye. Different marks (presence, lot numbers of CWT, VIE presence, color and location, and presence/absence of adipose clips) will distinguish stock (e.g. Catherine Creek), broodstock method (captive or conventional), and captive broodstock parental rearing method (freshwater natural, freshwater accelerated, saltwater natural, saltwater accelerated). The desired sample size for each treatment group is 60,000 when available. Fish receive CWT and adipose clips in June/July, 9-10 months before release, and VIE tags in October/November, 5-6 months prior to release.

Smolt-to-adult survival rates are primarily calculated from returns of coded wire tagged fish. Smolt-to-adult survival rates are also possible to determine for some groups of PIT-tagged fish. Approximately 21,000 Catherine Creek fish, 2,500 upper Grande Ronde River fish, and 16,000 Lostine River fish will be marked with passive integrated transponder (PIT) tags. Samples sizes for PIT-tagged fish will not be large enough to allow estimation of SARs for upper Grande Ronde River fish, and only periodically for Lostine River fish. Catherine Creek fish are PIT-tagged as part of the Comparative Survival Study. Fish receive PIT tags in October/November, 5-6 months before release.

Sampling of all treatment groups is conducted to estimate marking efficiency and retention. Five hundred fish per pond are sampled in late February, 1-2 months prior to release. If ponds are combined after CWT/adipose tagging, marking efficiency is also conducted prior to combining. Losses of fish and mark status are recorded throughout the rearing process and the numbers released are corrected for losses.

Estimating Returning Adults - CWT returns to streams are estimated from weir sampling and spawning ground surveys. All returning adult spring Chinook salmon collected at the weirs will be visually examined for VIE tags. All adults trapped at the weirs are scanned for CWTs and PIT tags using portable readers. Visual examination and scanning all adult spring Chinook salmon trapped at the weirs will provide information on strays.

Portable CWT scanners may also be used on spawning ground surveys to aid in identifying strays. Carcass recoveries during spawning ground surveys will provide age composition, CWT information by group, and ratios of hatchery to wild fish. The hatchery and age compositions of the carcasses recovered on spawning ground surveys or sampled at the weir will be applied to the population estimate to provided estimates of hatchery returns at age 4 and age 5. The estimate of age 3 fish returning will be estimated from fish sampled at the weirs. This age group is not representatively encountered during spawning ground surveys relative to ages 4 and 5. However, at the time age 3 fish are typically migrating past the weirs, weir efficiency is normally excellent. Therefore, this estimate is thought to be accurate. CWT recoveries for particular age and tag groups will be expanded by the total hatchery-origin population estimate to provide an estimate of total hatchery-origin spawners by group.

SAR Estimation - To calculate SAR for a brood year, the number of smolts released and the total number of spawners returning as age 3, age 4 and age 5 fish must be known. SAR is usually estimated as the total number of ages *t*+4 and *t*+5 returns divided by the total number of smolts of broodyear *t* released. SAR can also be estimated using all three return ages ((*t*+3, *t*+4, and *t*+5). No variance around each estimate of SAR is calculated. SAR will be estimated for a particular group (e.g. progeny of captive broodstock freshwater accelerated growth regime) or for pooled groups (e.g. all progeny of captive broodstock parents). The coded wire tag database maintained by the Pacific States Marine Fisheries Commission (PSMFC) under the Regional Mark Information System (RMIS) is the source of data on CWT lot number, location and date of recovery, and other data on individual fish.

PTAGIS, also maintained by PSMFC, is the source for tag numbers, lot, date and location of PIT-tagged fish recovered as adults. SARs using PIT tags may be estimated in a similar fashion to CWTs But with smaller release groups, there will be fewer opportunities for recoveries. The 2003 BPA proposal for the Comparative Survival Rte Study (CSS) of Hatchery and Wild Pit Tagged Chinook and Steelhead & Comparative Survival Study Oversight Committee (Project 199602000) has a detailed description of the methods used to calculate SAR using PIT tags.

Ocean and In River Harvest - Numerous state and federal agencies conduct statistically valid surveys along the Pacific Coast (Alaska, British Columbia, Washington, Oregon, and California) and Area 6 of the Columbia River to estimate total harvest by commercial, tribal, and recreational fisheries. The vast majority of harvest in the Columbia River occurs in Area 6, the region between Bonneville and McNary Dams. These data are summarized in annual reports issued by RecFIN and PacFIN projects of PSMFC. Ceremonial and subsistence fisheries conducted by tribal agencies typically harvest much smaller numbers of fish; data for these may be collected on an irregular basis.

RMIS retains data on CWT recoveries from all fisheries and the numbers of fish sampled. These data provide exploitation estimates for various CWT groups, which then may be expanded by total harvest to estimate the total numbers of CW-tagged fish harvested. Data from CWT recoveries from spawning ground surveys and in-basin and out-of-basin strays recovered during spawning ground surveys and at hatcheries are available from RMIS.

1.e.4 – Tributary specific SARs will be generated from the tributary specific smolt equivalents (see 1d) and age specific adult return abundance estimates (see 1a) for each tributary. SARs are calculated as the number of adults per brood year observed at the dam or upstream of the dam divided by the number of smolts from the same brood year that survived to Lower Granite Dam.

PIT tags are used to generate efficiency estimates of emigrating fish through the emigration traps and to provide life history specific migration timing and survival estimates to Lower Granite Dam and other mainstem dams. However, once at Lower Granite Dam, tagged and non-tagged fish can experience different migration routes. The current default operations at the hydro-facilities are to return to the river all PIT tagged fish entering the bypass facility, while the vast majority of non-tagged fish that enter the bypass facility are transported to below Bonneville Dam. This default operation incrementally increases the relative proportion of PIT tagged to non-PIT tagged fish in the river. With mortality rates higher in the river than on a barge, PIT tagged fish are lost at a higher rate relative to non-PIT tagged fish. This differential mortality will decrease (negatively bias) the number and the relative proportion of PIT tags that emigrate to the ocean. In addition, the magnitude of bias depends upon bypass efficiency, in-river survival, and transportation rates, all of which exhibit high annual variation. Thus PIT tagged fish no longer represent the general non-tagged population of fish after passing Lower Granite Dam and limits, if not eliminates, our ability to calculate representative smolt-to-adult survival rate (SAR) and returning abundance of the general population. SAR and adult returns calculated from adult PIT tag detections potentially only reflect fish that were bypassed or remained in the river undetected and not the entire emigrant group.

With the separation by code (SbyC) technology currently operating in the hydro-system bypass facilities, it is now possible to accurately represent non-PIT tagged fish emigrating through the hydro-system using a predetermined group of PIT tagged fish. PIT tag codes from the predefined group of PIT tags can be entered into the SbyC system and given a specific action. The SbyC system has the ability to bypass or transport all, a predetermined portion, or every n^{th} individual entering each bypass facility and can be modified or eliminated as desired at any time during the migration period. To accurately represent non-tagged fish, a "monitor mode" would be designated for a predefined group of PIT tags, resulting in "no action" taken on the detected PIT tags. The "monitor mode" group of PIT tags would be barged, bypassed, or remain undetected in the same relative proportions as non-PIT tagged fish. Returning PIT tagged adults would accurately represent non-tagged adults regardless of juvenile detection rates, transportation rates, in-river survival rates, and potential delayed mortality of in-river and transported fish. These adult PIT tag detections can then be used to calculate representative SARs and adult abundance estimates.

One draw back to the SbyC system and the "monitor mode" action is the loss of in-river juvenile survival rate estimates. Multiple mark-recapture estimators are generally applied to PIT tag detections through the hydro-system to estimate project specific survival and detection rates (bypass efficiency). For these estimators, at least two recapture periods are needed. For juvenile survival estimates to Lower Granite Dam, PIT tags must be available for detection at Lower Granite Dam and at Little Goose Dam. In general, PIT tags in the "monitor mode" group would likely be removed from the river system upon first detection thereby eliminating survival rate estimates from this group. To generate survival rates to Lower Granite Dam and through the remainder of hydro-system, a second group of PIT tags would be required to emigrate through the hydro-system, available for multiple detections.

Juvenile survival to Lower Granite Dam and smolt equivalents will be determined for all populations independently. Juvenile survival to other mainstem dams, specifically McNary and Bonneville, will be determined for each subbasin. The minimum number of PIT tags needed to generate life stage specific survival rates to Lower Granite Dam have been calculated and range from 500 to 1,500 tags depending upon life stage and natal stream (Lady et al. 2001). Detections from these groups will be modeled through the SURPH sample size program to obtain life-stage specific survival estimates from the natal stream to Lower Granite Dam. PIT tag groups of 8,000 or greater are necessary for estimates of juvenile survival to McNary and Bonneville dams.

Granite-to-Granite SARs and adult return predictions would be generated from the number or relative proportion of PIT tags at Lower Granite Dam. Life stage specific tributary-to-tributary SARs and adult return predictions would be generated from the number or relative proportion of each life stage PIT tagged at the natal stream. Using PIT tags and the SbyC system, calculated SAR's and adult returns would require minimal assumptions while confidence intervals of the

SAR or adult prediction would be solely based on emigration estimates and associated error and PIT tag proportion and associated error of the proportion.

Quantification of natural SAR (Lower Granite to Lower Granite) will be determined for each subbasin. The PIT tag group targeted for transport should be large enough to achieve sufficient adult returns for valid SAR estimates. We desire a minimum return of 30 adults per brood year. The number of transported fish needed depends upon in-river survival rates and ocean survival and ranges from 11,000 to 20,000. The CSS study currently uses a conservative 1% SAR from Granite-to-Granite to determine the number of tags needed.

Selecting tags for bypass and the SbyC system would occur from the parr and pre-smolt tag files sorted by date and time of tagging. The PIT tags would then be split into bypass and transport groups by systematic removal of tags or another appropriate randomized method. The tags slated for transport could then be sent to the PSMFC prior to smolt emigration.

Because of the uncertainty in the number of emigrants and screw trap capture probability selecting a representative sample of tagged smolts for bypass or the SbyC system is more problematic. In addition, due to the lead-time required for entering PIT tag codes into the SbyC system, PIT tags must be selected and codes sent to the PSMFC prior to spring smolt tagging. One option is for the first smolt emigrants (up to minimum number needed for survival estimate) being selected for bypass with all remaining fish to be entered into the SbyC system. Although this scenario splits the smolt group into early and late groups, the fact that smolts emigrate over a short time period may minimize any effect. Another option is to split each day's tagged fish (each weeks or each consecutive group of 100 tags) into bypass and SbyC groups. While this scenario minimizes temporal differences, the project risks not meeting the minimum tag number for survival estimates.

PIT tag detections at hydroelectric facilities will be downloaded from the PTAGIS database. PIT tag recoveries at mainstem dams will determine smolt migration timing, survival rates from the natal stream to Lower Granite Dam (LGJ), and total smolts reaching LGJ. Emigrant trap efficiency estimates are used to calculate the number and confidence interval of life history stage emigration from the natal stream. Life history stage specific migration timing and survival calculated from PIT tagged fish can then be applied to the estimated non-tagged emigrant population to generate an estimate and confidence interval of the number of emigrants that survived to the smolt stage at Lower Granite Dam (smolt equivalents). Survival of PIT-tagged fish to Lower Granite and Columbia River dams will be estimated by the SURPH2 model (Smith et al. 1994, Lady et al.2001). Smolt detections will also used to calculate SARs when tagged fish return as adults and are detected. Adult passage through the FCRPS will be monitored with queries to the PTAGIS database. SAR determination back to the tributary via PIT tags will be supported by PIT tag interrogation at currently operated adult trapping facilities on the Lostine River, Catherine Creek, and Upper Grande Ronde River. If SAR's are to be obtained for natural Chinook salmon adults returning to the Imnaha River then development of an adult interrogation/enumeration system needs to occur. The proportion of redds above and below the existing weir had been highly variable since 1986 (Carmichael et al. 1998). Furthermore, the location of the existing weir at rkm 74 is 42 rkm above the confluence of Big Sheep Creek. Spawning occurs in Big Sheep Creek and Lick Creek, a tributary of Big Sheep Creek (Note: The NEOH Core Team explored alternative weir locations in the Imanha River subbasin and determined the existing site to be the most feasible for escapement monitoring and broodstock collections). Conventional picket or video weirs for enumerating adults would not be feasible for the Imnaha River during most years because of the amount of discharge and turbidity. Other technologies more suitable for large turbid river systems, such as hydro-acoustics, will not be able to distinguish between returning natural and hatchery adult Chinook salmon on their own. We believe that existing PIT tag technology used in the fish ladders at mainstem dams can be used to determine the number of returning natural and hatchery Chinook salmon in the Imnaha River (Downing 2000). Tributary/subbasin SAR determination in the Imnaha River will require operation of an expanded antenna PIT-tag detector to detect PIT-tagged adults into the Imnaha River.

MANAGEMENT OBJECTIVE 2: MAINTAIN LIFE HISTORY CHARACTERISTICS AND GENETIC DIVERSITY IN SUPPLEMENTED AND UNSUPPLEMENTED CHINOOK SALMON POPULATIONS IN THE IMNAHA AND GRANDE RONDE RIVER SUBBASINS.

Monitoring and Evaluation Objective 2a. Determine adult life history characteristics of naturally produced fish in supplemented and unsupplemented populations in the Lostine, Minam, Wenaha, and upper Grande Ronde rivers and Catherine Creek and compare to pre-supplementation characteristics.

Ho: There is no difference in adult age-at-return structure over time between pre-supplemented populations and post-supplemented populations.
Ha: There is a significant difference over time in adult age-at-return structure between pre-supplemented population and post-supplemented population.

Ho: There is no difference in adult size-at-age over time between pre-supplemented populations and post-supplemented populations.
Ha: There is a significant difference over time in adult size-at-return between pre-supplemented population and post-supplemented population.

Ho: There is no difference in adult spawner sex ratio over time between pre-supplemented populations and post-supplemented populations.
Ha: There is a significant difference over time in adult spawner sex ratio between pre-supplemented population and post-supplemented population.

Ho: There is no difference in adult run-timing over time between pre-supplemented populations and post-supplemented populations.
Ha: There is a significant difference over time in adult run-timing between pre-supplemented population and post-supplemented population.

Status: Baseline monitoring of all adult life history traits in reference populations.

Four performance measures are used to monitor life history characteristics of natural-origin adults and test for changes due to hatchery supplementation. Key performance measures are age-at-return, size-at-age, sex ratios, and adult run-timing. Age-at-return is described as proportional distribution, developed through run-reconstructions over time for each cohort. Size-at-age is expressed as a frequency distribution of fork lengths (5 cm groupings) by sex for a cohort. Adult spawner sex ratio by return year will be summarized as the percentage natural origin females in the total escapement of natural origin fish for that year. Adult run-timing is expressed through summary statistics of 10%, 50%, 90% fish arrival (described by Julian day) at Lower Granite Dam via PIT tags, actual fish observations at weirs, and remotely detected fish escapement via acoustic imaging and PIT tag array antennae. Comparison of run-timing summary statistics to the baseline average will support categorization of run-timing as early, typical, or late. Adult run-timing will also be expressed as a frequency distribution by week. With each week's escapement being expressed as a percentage of the total run over time. Data will be summarized for natural origin spawners and will be collected at the population scale.

Comparing pre- and post-supplementation conditions must take into account environmental variability. Therefore, we use reference streams (controls) to remove the temporal variability in testing. We examine adult life history characteristics of pre-supplementation and post-supplementation populations that are *relative to* those of reference population. For example, we calculate a difference value over time between an adult life history characteristic of a pre-supplemented population and that of reference population, and between an adult life history characteristic of a post-supplemented population and that of reference population. The calculated difference value (i.e. the relative value to reference population) over time shows whether they are constant over time between pre-supplementation and post-supplementation. Pre-supplementation data varies by stream and performance measure. Generally, the data series described in 1.d.1 applies here with a reduced time series of data for run-timing.

A simple t-test is appropriate because we compare two populations (pre-supplementation and post-supplementation populations) in a relative value of an adult life history characteristic to reference population and years are replicates.

As long as adult life history characteristics are expressed as a category or a factor (e.g. age groups for age, male and female for sex, early and late for run timing), and when we compare two populations (pre-supplementation and post-supplementation populations) with *all* available adult life history characteristics in the relative values to reference population, the data can be arranged in a multi-dimensional contingency table where variables are all available adult life history characteristics. A log-linear model is an efficient test method for each year. When data of all years are used, multi-factor ANOVA (i.e. multi-variable regression model) is appropriate where years are replicates.

We determine whether migration timing (frequency distributions) differs between populations using a Kruskal-Wallis one-way analysis of variance on ranked dates of detection, expressed as day of the year, of expanded fish numbers. When significant differences are found, we use Dunn's pair-wise multiple-comparison procedure (α = 0.05) to further analyze the data (Norusis 1999). ANOVA analysis can also be used to characterization of trends (population description) over time by considering time (year) as an explanatory variable not as replicates.

We will test at 5% Type I error (i.e. $\alpha = 0.05$), and show the p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

Monitoring of adult life history characteristics will occur annually for the duration of the program operations. Testing for change will occur in 5-year intervals. Ideally, this suite of life history characteristics would be part of a core set of performance measures monitored indefinitely for population status descriptions. Examination of pre and post-supplementation characteristics will occur in Lostine River, Catherine Creek, and the upper Grande Ronde River. Monitoring will occur in the Minam and Wenaha rivers (reference streams) and the Imnaha river during program operation, with a reduce set of key streams being monitored post program.

Methods

2.a.1 - *Age-at-Return* is influenced by inheritance, gender, growth and environmental factors and may reflect changes resulting from domestication, artificial selection or growth regime. Therefore this trait can be used as a phenotypic standard set by natural fish to indicate the appropriate age structure of post-supplementation natural population or hatchery-origin fish segment. Age-at-return is derived from ageing methodology and run-reconstruction methods described in section 1a.

2.a.2 - *Adult size-at-return* is primarily a function of ocean growth and duration of ocean residence. Length is a beneficial descriptor for comparing relative growth experienced by fish during ocean rearing. Fork lengths of natural origin fish will be obtained from carcasses during spawning ground surveys and measurements from fish interrogated at the weirs. Known or estimated fish age assignments used to partition for length measurements by to calculate an average fork length by age and sex with associated variance.

2.a.3 – *Adult spawner sex ratio* will be quantified from carcass surveys (see 1.a.2). In order to examine variation of sex ratio independently from age-at-return and relative age class abundance, sex ratio for age IV natural origin fish will be utilized. Age IV fish are used to maximize sample size.

2.a.4 – *Adult run-timing* is an important trait for the long-term survival of an anadromous population. Streams may not be in suitable condition if adult return in not adapted to the watershed. Spawning too early or too late adversely affects embryo development and fry survival (Gharrett and Smoker 1993). Spawning too early for stream conditions can have a negative effect on spawner survival (Leider et al. 1984). Although timing is mediated somewhat by temperature and flow, it is primarily under genetic control (Gharrett and Smoker 1993). Run-timing can be influence by age-at-return. Run timing will be described by age (specifically, jacks vs adults) when sample size allows.

Run-timing as described by adult passage at Lower Granite Dam relies on detection of population specific adults via PIT tags. It requires a sufficient number of PIT tags are representatively applied to achieve significant detections upon return. PIT tagging goals will not be driven by this performance measure. If adequate detections (minimum of 30) are achieved, the Julian date for the 10%, 50%, and 90% passages will be calculated. PIT tag detection and data storage will rely on PTAGIS program.

Run-timing of adults to specific tributaries will be determined by summarizing daily adult enumeration by week in relation to season-wide abundance in frequency distribution from weirs and fish counting stations (see section 1.a.1 and 1.d.12). Julian date of the 10%, 50%, and 90% passage dates to tributary is generated directly from cumulative capture data. Adjustments to run-timing estimates will be made if portions of the run are not directly enumerated via weir or fish counting stations. In years with significant gaps in direct detections, run-timing estimates will not be characterized. In streams with remote PIT tag detection antennae (see 1.e.4; Imnaha River) run-timing will also be established via PIT tag detections similar to Lower Granite passage characterization described above.

<u>Monitoring and Evaluation Objective 2b</u>. Determine juvenile life history characteristics of naturally produced fish in supplemented populations in the Imnaha, Lostine, and upper Grande Ronde rivers and Catherine Creek and compare to pre-supplementation characteristics.

Ho: There is no difference in juvenile age-at-emigration over time between pre-supplemented populations and post-supplemented populations.
Ha: There is a significant difference over time in juvenile age-at-emigration between pre-supplemented population and post-supplemented population.

Ho: There is no difference in size-at-emigration over time between pre-supplemented populations and post-supplemented populations.
Ha: There is a significant difference over time in size-at-emigration between pre-supplemented population and post-supplemented population.

Ho: There is no difference in juvenile emigration-timing over time between pre-supplemented populations and post-supplemented populations.
Ha: There is a significant difference over time in juvenile emigration-timing between pre-supplemented population and post-supplemented population.

Status: Baseline monitoring of all juvenile life history traits in reference populations.

Three performance measures are used to monitor life history characteristics of natural-origin juveniles and test for changes due to supplementation actions via representative juvenile emigrant trapping. Key performance measures are age-at-emigration, size-at-emigration, and emigration timing. Age-at-emigration is described as a proportional distribution of freshwater age at smolting (tributary specific spring emigrants). Size-at-emigration is characterized by the mean fork length and condition factor by life stage of juveniles at emigrating from natal stream. Juvenile emigration-timing is described for two locations; tributary mouth and Lower Granite Dam. Emigration-timing from the tributary is as the proportional distribution by life stage of juveniles as they leave the natal stream. *Mainstem-arrival timing* is expressed through summary statistics of 10%, 50%, 90% fish arrival (described by Julian day) at Lower Granite Dam via PIT tags. Comparison of run-timing summary statistics to the baseline average will support categorization of run-timing as early, typical, or late. Juvenile emigration-timing will also be expressed as a frequency distribution by week of tributary emigrants. With each week's emigration estimate being expressed as a percentage of the total annual emigration.
To remove the temporal variability in testing, we use reference streams (control). We use juvenile life history characteristics of pre-supplementation and post-supplementation

populations that are *relative to* those of reference population. For example, we calculate a difference value over time between an adult life history characteristic of a pre-supplemented population and that of reference population, and between an adult life history characteristic of a post-supplemented population and that of reference population. The calculated difference value (i.e. the relative value to reference population) over time shows whether they are constant over time between pre-supplementation and post-supplementation. Juvenile life history pre-supplementation data varies by stream and performance measure. Generally, the data sets are available from 1995 for the Lostine River, 1999 for the Minam River, 1993 for Catherine Creek, 1992 for the Upper Grande Ronde River. Monitoring of certain aspects of juvenile life history in the Imnaha River has been ongoing since 1993.

A simple t-test is appropriate because we compare two populations (pre-supplementation and post-supplementation populations) in a relative value of a juvenile life history characteristic to reference population. Years are replicates.

As long as juvenile life history characteristics are expressed as a category or a factor (e.g., age groups for age, portion by life stage for emigration, early and late for emigration timing), and when we compare two populations (pre-supplementation and post-supplementation populations) with *all* available adult life history characteristics in the relative values to reference population, the data can be arranged in a multi-dimensional contingency table where variables are all available adult life history characteristics. A log-linear model is an efficient test method for each year. When data of all years are used, multi-factor ANOVA (i.e. multi-variable regression model) is appropriate where years are replicates.

We determine whether emigration timing (frequency distributions) differs between populations using a Kruskal-Wallis one-way analysis of variance on ranked dates of detection, expressed as day of the year, of expanded fish numbers. When significant differences are found, we use Dunn's pair-wise multiple-comparison procedure (α = 0.05) to further analyze the data (Norusis 1999). ANOVA analysis can also be used to characterization of trends (population description) over time by considering time (year) as an explanatory variable not as replicates.

We will test at 5% Type I error (i.e. $\alpha = 0.05$), and show p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

Monitoring of juvenile life history characteristics will occur annually for the duration of the program operations. Testing for change will occur in 5-year intervals. Ideally, this suite of life history characteristics would be part of a core set of performance measures monitored indefinitely for population status description. Examination of pre and post-supplementation characteristics will occur in Lostine River, Catherine Creek, and the upper Grande Ronde River. Monitoring will occur in the reference streams and the Imnaha River during program operation with a reduce set of key streams being monitored post program.

Methods

2.b.1 – *Age-at-emigration* is characterized by freshwater age at smolting as the proportion of brood year smolts migrating out of tributary specific areas of Type 1 yearlings and Type 2 yearlings. Initial assignment of brood year for individual fish will be determined by length frequency distributions. Validation of length frequency age assignments will be accomplished by scale pattern analysis of 100 smolts annually. Scales will be sampled to establish circuli patterns reflecting age and growth rate. Monitoring of delayed migration of juvenile Chinook salmon that spend a second year in fresh water down stream of emigration traps is determined from PIT tag detections at the Snake and Columbia River hydro-project PIT tag interrogation and trap sites.

2.b.2 - *Size-at-emigration* is quantified for each life stage as described in 1.d.14. Fork length (mm) and weight (g) are representatively collected weekly from at least 100 emigrating juveniles captured in emigration traps. Mean fork length and variance for all samples with in a life stage specific emigration period are generated. Condition factor by life stage of juveniles is also generated with the formula:

$$K = (w/l^3)(10^4)$$

where K is the condition factor, w is the weight in grams (g), and l is the length in millimeters (Everhart and Youngs 1992).

2.b.3 - Description of juvenile life stages and methods for determining relative abundance by life stage is provided in section 1.d.14. The relative proportion of juveniles moving past the emigration traps by life stage and *mainstem arrival-time* will describe *emigration timing*. Relative proportion of emigrants by parr, presmolt, and smolt life stages is derived from seasonal population estimates. Weekly population estimates are presented either as proportional or cumulative distributions over time relative to the total escapement.

Migration timing past Lower Granite Dam is estimated for each tag group by expanding daily numbers of PIT tag detections according to the proportion of river flow spilled each day. This procedure is necessary because some fish may pass undetected over the spillway and the amount of spill varies throughout the migration season. We assume the proportion of fish that pass over the spillway (spill effectiveness) is directly related to the proportion of flow spilled. This assumption conforms fairly well to data obtained using non-species-specific hydro-acoustic methods (Kuehl 1986). We also assume there is no temporal variation either in the proportion of fish diverted from turbine intakes into the bypass system (fish guidance efficiency) or in the proportion of fish that pass through the surface bypass collector. We make these assumptions in light of evidence to the contrary (Giorgi et al. 1988, Swan et al. 1986, Johnson et al. 1982) because the data required to account for such variation are unavailable. The extent to which our results may be biased would depend on the overall rates of fish passage via the bypass system and surface bypass collector, and on the degree to which daily rates of fish passage by these routes may have varied throughout the migration seasons. The number of fish migrating past Lower Granite Dam by week is calculated by multiplying the number of fish detected each day by a daily expansion factor, which is calculated as:

$$\text{Expansion factor} = (\text{powerhouse flow} + \text{spillway flow})/\text{powerhouse flow}.$$

Daily products are added for each week and rounded to the nearest integer. Median, 10%, and 90% detection dates are reported for each tag group. Medians are determined for detection dates weighted by expanded fish numbers. Median detection dates for the spring tag groups may reflect the dates fish are tagged in addition to the migration pattern. For this reason, median detection dates for the spring tag groups may be biased. The time taken for spring tagged parr to reach Lower Granite Dam from the screw trap is summarized for each location. Mainstem arrival timing will be generally categorized as early, typical, or late by the cumulative percentage of the population detected by the historical median arrival date for that population.

Monitoring and Evaluation Objective 2c. Monitor genetic characteristics in supplemented and unsupplemented populations to assess degree and rate of change.

Ho: Levels of genetic variability are the same in hatchery, natural, and wild populations.
Ha: Levels of genetic variability is significantly different between hatchery, natural, and wild populations.

Ho: Levels of genetic variability do not change over time.
Ha: Levels of genetic variability fluctuates over time.

Ho: Inter-locus variance of F (a measure of allele frequency change over time) is no larger than would be expected if all changes are due to sampling error and genetic drift.
Ha: Inter-locus variance of F is significant beyond factors of sampling error and genetic drift.

Ho: The relationship between wild N_e and N in natural/wild populations is the same in years of high and low escapements.
Ha: The relationship between wild N_e and N in natural/wild populations is affected by fluctuations in escapement.

Ho: Genetic differences among populations are so small and temporal variation so great that relationships among samples, and effects of supplementation, cannot be meaningfully evaluated. Note: This general hypothesis can be tested for each supplementation program in each of the species (8 tests altogether). If the hypothesis is rejected, then we can evaluate power of the combined genetic data (allozymes + DNA) to detect genetic differences of various magnitudes. Taken as a whole, these results should provide considerable insight into the general usefulness of genetic monitoring and evaluation programs.
Ha: Genetic difference among populations can be detected and significance of the difference can be described.

Ho: There are no genetic differences among natural populations, except those that can be attributed to sampling error and random year-to-year variation.
Ha: Significant genetic differences among natural populations exist beyond those that can be attributed to sampling error and random year-to-year variation.

Ho: Genetic affinities among geographic populations change randomly over time.
Ha: Genetic affinities among geographic populations are correlated over time.

Ho: Levels of gene flow among populations are less than X individuals per generation.
Ha: Levels of gene flow among populations are greater than X individuals per generation.

A variety of performance measures will be used to characterize genetic structure and variability within populations under this objective using microsatellite and allozyme analyses.

Measure levels of genetic variability in each population: Genetic variability within populations will be evaluated in a number of different ways. Comparisons of variability in hatchery, natural, and wild populations will be made and changes in levels of variability will be evaluated through time. Observed variability will also be compared.

Estimate effective population size (N_e) and the ratio N_e/N for each population**--**Fixation indices and gametic disequilibrium will be used to estimate and evaluate the relationship between effective population size and census size (N) estimated from redd counts, spawner surveys, and population enumeration.

Evaluate population genetic structure of natural and wild populations--Fixation indices and hierarchical gene diversity analyses will be used to partition genetic variation into spatial and temporal components. These relationships will be used to estimate levels of gene flow among populations.

Document selective forces and genetic effects of supplementation on target and non-target populations**--**Indices of genetic differentiation will be calculated between hatchery and natural, and hatchery and wild populations. Patterns of genetic change will be examined through time in the three classes of populations.

Genetic stock structure and inter-relationship of populations is a critical aspect of endemic species fisheries management. Maintaining adequate genetic diversity and accounting for reproductive effectiveness in management actions are central when dealing with endangered species. As such, developing a core understanding of the genetic structure and linkages between populations and population segments is essential and will require continual monitoring. Sampling is required in the Imnaha River, Lostine River, Catherine Creek, and Upper Grande Ronde River (treatment streams) and the Minam and Wenaha rivers (reference streams).

Methods

2.c.1 – Samples will be collected annually from hatchery, wild, and natural populations involved in the study. Fifty to 100 fish per population sample will be collected. The primary collection method throughout this study will be nonlethal fin clips to minimize impact on at-risk wild and natural populations. Hatchery samples are generally parr or presmolts shortly prior to release. Field samples involve parr or smolts. Field collections are made with seines or electroshockers and are conducted in accordance with NMFS ESA permit #1406, study 2. Allozyme samples are frozen in the field on dry ice or liquid nitrogen and transported or shipped to Seattle for storage and analysis at -80 C. During dissection for allozyme analysis, subsamples of tissue are preserved in ethanol and logged into the Conservation Biology Division's Tissue Archive.

All samples taken for this project since 1989 have been deposited in the Conservation Biology Tissue Archive (as ethanol-preserved tissue samples). An important subsidiary goal of this project is to go back and rerun representative samples for new microsatellite markers and incorporate both old and new data into our growing Columbia River genetic baseline data sets for both steelhead and Chinook. Thus, we are coordinating Snake River data collection with other projects both in our lab and between ours and other labs in order to provide the most comprehensive picture possible for genetic stock structure for these two important species.

2.c.2 - Protein electrophoresis--Protein electrophoresis follows the procedures of Aebersold et al. (1987). Laboratory procedures have been standardized among the agencies participating in the Coast-wide Genetic Stock Identification Consortium. For each fish, genotypic data will be gathered for a series of enzyme systems coding for approximately 40-60 gene loci known to be variable in Chinook salmon. The number of loci that are polymorphic in any given sample will be fewer and varies somewhat geographically, but is typically about 20-40. It will be some time before DNA data can be collected for past samples archived in the course of this study. Until that time we seek continued utility from the substantial accumulation of allozyme data.

2.c.3 - DNA methods: In recent years, the use of DNA techniques has added significantly to the repertoire of research tools available to the salmon genetics community (Park and Moran 1994; Moran 2002). DNA markers have served to augment allozyme data, providing additional power to identify subtle differences among populations and small genetic changes through time. They also simplify field collection of tissues, because, pickled in alcohol, this material can be stored and shipped at ambient temperature, rather than requiring dry ice or liquid nitrogen. Further, even small juveniles can be easily sampled nonlethally by taking small fin clips. Most importantly for this work, it is possible to sample historical populations available as archived scale collections (Moran and Baker 2002).

In this study, two major classes of nuclear DNA markers are continually being developed, implemented, and refined: 1) single nucleotide polymorphisms (SNPs) in the introns, 3' untranslated regions (3' UTRs), and other noncoding sequences of nuclear genes; and 2) highly variable simple sequence repeats, or microsatellite loci. Although some developmental work continues on SNPs, the primary focus is on microsatellite loci.

The microsatellite methods are similar to those presented in Olsen et al. (1996) and Neff et al. (2000). In this case, PCR primers amplify tandem simple-sequence repeats (e.g., the DNA bases CACACA...). Allelic variation is present at these loci in the number of copies of the repeat unit and thus the size of the PCR product. Many microsatellite primer pairs are now available for Pacific salmon. There are also collaborations within the Conservation Biology Division that are especially important to this project.

During this performance period, our DNA efforts will focus on surveying larger numbers of individuals and populations for the markers we have already developed. We will take advantage of the ability to sample fin clips nonlethally to gather an unbroken temporal series of data from depressed natural populations of spring/summer Chinook salmon. We will also attempt to collect historical genetic information from archived scale samples to allow a comparison of genetic profiles pre- and post-supplementation. Preliminary work with Chinook salmon scale collections from other regions shows considerable promise for the use of scale archives as a viable approach for characterizing historic populations (Moran and Baker 2002). These methods should be particularly useful in evaluating the effects of the prolonged propagation of Rapid River Chinook on natural population structure in the Grande Ronde basin.

Although we continue to rely heavily on microsatellite markers for both pedigrees and population genetics we continue to devote some resources to developing SNPs and finding more efficient methods of assaying them on a large scale (Objective 2). High-throughput genotyping is a topic of acute interest in human genetics and there have been significant advances (Mir and Southern 2000) since we applied ligation capture (Park et al. 1994) and allele-specific PCR (Moran et al. 1998) to Pacific salmon. Recent efforts in our lab have focused on dye-quench fluorescent assays, specifically Applied Biosystem's SNAP assay. Recent studies suggest other promising alternatives related to dye-quench technology (Morin et al. 1999; Myakishev et al. 2001). We believe that DNA sequence variation represents a significant untapped resource with respect to understanding selective forces and ultimately the specific mechanisms by which populations adapt to their environments (Ford 2000; 2002b).

Data analysis--Electrophoretic phenotypes visualized on starch gels are interpreted as genotypes according to guidelines discussed by Utter et al. (1987). A chi-square test is used to compare genotypic frequencies at each variable locus in each population with frequencies expected under Hardy-Weinberg equilibrium. This test can be useful in detecting artifactual (nongenetic) variation. The method of Waples (1988) is used to evaluate genotypes and estimate allele frequencies at isoloci (duplicated gene loci). A variety of standard statistical analyses are routinely applied to the data (e.g., computing heterozygosity, gene diversity, number of alleles per locus, genetic distances, and *F*-statistics; testing for heterogeneity of allele frequencies among populations).

2.c.4 - In addition to these analyses, a number of more specialized analyses are used to estimate effective population size. As the primary goal of this project is to study genetic changes over time in natural and wild populations resulting from supplementation, it is necessary to consider factors other than hatchery-wild genetic interactions that can lead to genetic change. Because supplementation is typically considered only when natural abundance is low, the effects of random genetic drift due to finite population size must be considered in evaluating observed genetic changes. Our methods for estimating effective population size include the following:

Quantifying allele frequency change. The statistic used to measure the magnitude of genetic change is $\hat{F} = (P_1 - P_2)^2 / [(\overline{P}(1-\overline{P})]$, where P_1 and P_2 are allele frequencies in samples taken at two different times and is the mean of P_1 and P_2. $\hat{F}$ is computed for each gene locus surveyed, and a mean $\hat{F}$ over all loci in a comparison of temporally spaced samples is also computed.

Testing for selection. Although there is a body of evidence suggesting that the enzymatic gene loci sampled by electrophoresis in general are largely unaffected by natural selection, it is important to evaluate this assumption because strong selection would complicate the interpretation of changes within populations and interactions between populations. If the loci used are effectively neutral, they all should be affected by genetic drift to approximately the same degree. The method of Lewontin and Krakauer (1973) will be used to test the hypothesis that the variance of single locus values is no larger than expected from random sampling error. DNA sequence data will be subjected to additional tests of neutrality, including non-synonymous to synonymous substitution rates and others (reviewed by Ford 2002b).

Measuring gametic disequilibrium. The statistic r^2, the squared correlation of alleles at different gene loci, are computed for each pair of loci in each sample. The overall mean r^2 value is a measure of gametic disequilibrium, or non-random associations across loci.

Estimating N_b. After omitting any loci identified by the test for selection, the mean value (computed as in #1) is used to estimate N_b, the effective number of breeders each year. The procedure follows the "temporal method" for estimating effective population size (Krimbas and Tsakas 1971; Nei and Tajima 1981; Waples 1989), as modified specifically for Pacific salmon (Waples 1990).

Because $\hat{F}$ is known to be distributed approximately as chi-square, confidence limits can be placed on the estimate of N_b. The mean value of r^2 provides an independent method for estimating N_b, based on the method developed by Hill (1981), and confidence limits can also be placed on this estimate.

In many cases, analyses of DNA and allozyme genotypes are identical. However, the high levels of polymorphism encountered with microsatellites present both special challenges and special opportunities. We will use current consensus methods for obtaining parameter estimates and population genetic metrics from the broad frequency distributions typical of microsatellite loci (Raymond and Rousset 1995; Rousset and Raymond 1995; Goudet et al. 1996). Using both DNA and allozyme data we will apply some of the maximum likelihood methods that have recently been proposed for estimating migration rates (Beerli and Felsenstein 1999; Nielsen and Slatkin 2000) and effective population size (Anderson et al. 2000). Also, Kitada et al. (2000) have presented a Baysian procedure for estimation of effective population size that models uncertainty in allele frequency estimation. It is not yet clear how these methods will perform without extensive modification to incorporate the complex age structure and semi-overlapping generations in salmon and steelhead (Waples 1990a 1990b).

Based on preseason surveys of juvenile distribution and redd counts from the previous year, collections will be arranged and coordinating wherever possible with other field activities. Samples will include hatchery, natural, and wild collections representing the study sites in different basins. Assumption: Sampling is random with respect to the entire population. Again, some departures from strict randomness are expected, but non-representative samples can bias results. In some cases, a sample of progeny from a relatively few individuals can be identified by an unusually low estimated ratio of effective to total population size.

Preliminary analyses of DNA and allozyme data will be conducted to assure their integrity and identify any potential errors or sampling anomalies. Microsatellite and allozyme variation is largely neutral. Undoubtedly some departures from strict neutrality exist, but substantial departures might bias conclusions drawn from the data. We can test that genotypic frequencies do not differ from those expected under Hardy-Weinberg equilibrium.

Whenever possible, co-managers will collect fin or opercle punches from sixty adults from each known spawning aggregate. A collection of 58 samples yields a 95% probability that alleles occurring at a frequency of 5% or greater will be encountered within the sample group. Collecting tissue from a few additional adults is recommended, particularly if the tissue is from carcass surveys, since DNA may be degraded.

<u>MANAGEMENT OBJECTIVE 3:</u> OPERATE THE HATCHERY PROGRAM SO THAT LIFE HISTORY CHARACTERISTICS AND GENETIC DIVERSITY OF HATCHERY FISH MIMIC NATURAL FISH.

<u>Monitoring and Evaluation Objective 3a</u>. Determine and compare genetic characteristics of hatchery and natural fish in Catherine Creek, Lostine, upper Grande Ronde and Imnaha populations.

Ho: There are no genetic differences between hatchery populations and natural populations they were derived from.
Ha: Significant genetic differences exist between hatchery and natural population segments they were derived from.

Ho: Populations that have been supplemented show the same magnitude of genetic change over time as unsupplemented populations.
Ha: The magnitude of genetic change over time has been altered in supplemented populations.

Ho: The relationship between N_e and N is the same in hatchery and natural populations.
Ha: The relationship between N_e and N is significantly reduced for hatchery and natural populations.

Ho: Non-target wild populations have not been genetically affected by hatchery strays.
Ha: Non-target wild populations have been genetically altered by hatchery strays.

The suite of performance measures used to characterize genetic structure and variability within populations described for Monitoring and Evaluation Objective 2c above also apply to this objective. The focus of this objective is to examine the within tributary relationship of hatchery and naturally produced fish and the impacts of hatchery origin strays to reference populations. Microsatellite and allozyme analyses are applied.

Several different methods can be employed in evaluating genetic effects on natural/wild populations, depending on the type of data available. The most important question is whether pre-supplementation baseline data are available for the hatchery and natural/wild stocks involved.

a. Baseline data available. In the short term (up to about 1 generation after supplementation), the proportion of fish of hatchery and wild origin can be estimated using the mixture model of Milner et al. (1981). A variety of methods can be used to place confidence limits on the estimated contributions. In the longer term, the relative contribution of two original gene pools to a hybridized mixture can be estimated using the method discussed by Glass and Li (1953). This approach can be modified to take genetic drift into consideration (Thompson 1973).
b. Baseline data not available. Power to resolve the genetic contribution of hatchery and natural fish is reduced considerably if pre-supplementation baseline data are not available. However, the null hypothesis that the existing population represents a single gene pool (rather than a mixture of gene pools) can still be

tested using gametic disequilibrium analysis. Gametic disequilibria are correlations of alleles at different gene loci, and one cause of these disequilibria is a mixture of different gene pools. Waples and Smouse (1990) showed that the power to detect mixtures of salmonid populations can be reasonably high provided that there were sufficiently large genetic differences between the stocks before mixing. This method, however, has limited power to detect mixtures involving populations that are genetically similar.

Genetic stock structure and inter-relationship of populations is a critical aspect of endemic species fisheries management. Maintaining adequate genetic diversity and accounting for reproductive effectiveness in management actions are central when dealing with endangered species. As such, developing a core understanding of the genetic structure and linkages between populations and population segments is essential and will require continual monitoring. Sampling is required in the Imnaha River, Lostine River, Catherine Creek, and Upper Grande Ronde River (treatment streams) and the Minam and Wenaha rivers (reference streams).

Methods

3.a.1 – See section 2.c.1-4 for description of methods.

3.a.2 - If the level of effective gene flow between the hatchery and naturally spawning salmonid aggregates is large, there will likely be no detectable difference in genetic composition using the neutral markers. Should detectable differences remain, it would suggest that hatchery-reared adults suffer limited reproductive success under natural conditions and/or natural spawners collected as broodstock suffer high egg to smolt mortality in the hatchery environment. Observed differences might also suggest that rates of infusion of naturally spawned fish into the broodstock are too low, or that the rate of hatchery outplanting is too low (unless of course the goal is to avoid introgression between the two groups).

Two data components are necessary to address this question: 1) demographic data such as adult to adult return rates of hatchery-reared and naturally spawned salmon; and 2) a measure of effective population size for both population components. The first data type is addressed by monitoring describe under 1.a. Calculation of effective population size will be pursued using multiple estimators. Crow and Denniston (1998) present an approach for estimation of variance effective population size, and Lande and Barrowclough (1987) present an approach for estimating inbreeding effective population size. Both analyses should be performed for hatchery broodstock and natural spawners. A composite effective population size for both groups can be calculated using an approach presented by Ryman and Laikre (1991). Because the NEOH program is designed to augment natural production, co-managers will seek to avoid a decrease in the composite inbreeding and variance effective population size. If the naturally spawning population is reproducing at a rate below replacement, it may be impossible to increase the composite inbreeding and variance effective population size, however avoiding a net decrease would be a benefit to conservation.

An overall assessment will be made of the power of genetic markers to provide monitoring and evaluation information that is useful for an adaptive management approach to supplementation. We already know that this approach can be very useful in some instances and less useful in others, but we continue to make this evaluation as the data accumulate.

<u>Monitoring and Evaluation Objective 3b</u>. Determine and compare adult life history characteristics between hatchery and natural fish in Catherine Creek, Lostine, upper Grande Ronde and Imnaha rivers.

Ho: There is no difference in adult age-at-return structure over time between hatchery and natural fish within each supplemented population.
Ha: There is a significant difference over time in adult age-at-return structure between hatchery and natural fish within each supplemented population.

Ho: There is no difference in adult size-at-age over time between hatchery and natural fish within each supplemented population.
Ha: There is a significant difference over time in adult size-at-return between hatchery and natural fish within each supplemented population.

Ho: There is no difference in adult spawner sex ratio over time between hatchery and natural fish within each supplemented population.
Ha: There is a significant difference over time in adult spawner sex ratio between hatchery and natural fish within each supplemented population.

Ho: There is no difference in adult run-timing over time between hatchery and natural fish within each supplemented population.
Ha: There is a significant difference over time in adult run-timing between hatchery and natural fish within each supplemented population.

Ho: There is no difference in fecundity over time between hatchery and natural fish within each supplemented population.
Ha: There is a significant difference over time fecundity between hatchery and natural fish within each supplemented population.

Ho: There is no difference in egg size over time between hatchery and natural fish within each supplemented population.
Ha: There is a significant difference over time in egg size between hatchery and natural fish within each supplemented population.

Five performance measures are used to monitor life history characteristics of hatchery and natural-origin adults and test for divergence of the hatchery production group from natural production characteristics. Key performance measures are age-at-return, size-at-return, sex ratios, fecundity, and adult run-timing. Measurement of these same performance measures (with the exception of fecundity) for natural populations is described under objective 2a. Data for hatchery origin adults will be summarized similarly. Fecundity will be presented as the number eggs by age class and size group for hatchery origin and natural origin fish independently.

A simple t-test is appropriate because we compare two population segments (hatchery origin and natural-origin) directly for each adult life history characteristics over time. Years are replicates.

We determine whether migration timing (frequency distributions) differs between populations using a Kruskal-Wallis one-way analysis of variance on ranked dates of detection, expressed as day of the year, of expanded fish numbers. When significant differences are found, we use Dunn's pair-wise multiple-comparison procedure (α = 0.05) to further analyze the data (Norusis 1999).

ANOVA analysis can also be used to characterization of trends (population description) over time by considering time (year) as an explanatory variable not as replicates.

We will test at 5% Type I error (i.e. $\alpha = 0.05$), and show p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

Monitoring of adult life history characteristics will occur annually for the duration of the program operations. Testing for change will occur in 5-year intervals. Examination will occur in Imnaha River, Lostine River, Catherine Creek, and the upper Grande Ronde River.

Methods

3.b.1 - Age-at-Return (1.a and 2.a.1), Adult size-at-return (2.a.2),Adult spawner sex ratio (1.a.7), Adult Run-timing (2.a.4).

3.b.2 – Fecundity and egg size over time of both hatchery and natural-origin fish will be collected from fish used in the broodstock. Two primary methods are used; 1) total weight of eggs and 2) egg displacement. Data from each method will be expanded to a total egg estimate. Egg size will be determined from a 50 egg sample per female.

3.b.3 - Spawn timing for Chinook salmon is influenced by inheritance, so any inter-generational change in spawning time is likely to reflect a genetic change. Spawning time at hatcheries will be monitored as the dates of 20%, median, and 80% of spawning completion for the number of females spawned by origin.

Monitoring and Evaluation Objective 3c. Determine and compare smolt migration characteristics between natural and hatchery smolts in the Imnaha, Lostine, upper Grande Ronde rivers and Catherine Creek.

Ho: There is no difference in juvenile age-at-emigration over time between hatchery and natural fish within each supplemented population.
Ha: There is a significant difference over time in juvenile age-at-emigration between hatchery and natural fish within each supplemented population.

Ho: There is no difference in size-at-emigration over time between hatchery and natural fish within each supplemented population.
Ha: There is a significant difference over time in size-at-emigration between hatchery and natural fish within each supplemented population.

Ho: There is no difference in juvenile emigration-timing over time between hatchery and natural fish within each supplemented population.

Ha: There is a significant difference over time in juvenile emigration-timing between hatchery and natural fish within each supplemented population.

A suite of three performance measures is used to monitor life history characteristics of hatchery and natural-origin juveniles and test for divergence of the hatchery production group from natural production characteristics. Key performance measures are age-at-emigration, size-at-emigration, and emigration timing. Measurement of these same performance measures for the naturally produce population segment is described under objective 2b. Age-at-emigration of the hatchery production group will be characterized as a Type 1 (yearling) smolt. Adjustment to a proportional distribution will be made if a significant level of delayed emigration is documented via PIT tag detections at Lower Granite Dam. Size-at-emigration of the hatchery production group is characterized by the mean fork length and condition factor as determined during pre-release sampling. Juvenile emigration-timing for hatchery fish will be described for two locations; acclimation facilities and Lower Granite Dam. Volitional movement from acclimation facilities will be characterized as a proportional distribution over the release period. *Mainstem-arrival timing* expression will be consistent with methods in section 2b.

A simple t-test is appropriate because we compare two population segments (hatchery origin and natural-origin) directly for each juvenile life history characteristics over time. Years are replicates.

We determine whether migration timing (frequency distributions) differs between populations using a Kruskal-Wallis one-way analysis of variance on ranked dates of detection, expressed as day of the year, of expanded fish numbers. When significant differences are found, we use Dunn's pair-wise multiple-comparison procedure (α = 0.05) to further analyze the data (SPSS Inc. 1992–1997).

ANOVA analysis can also be used to characterization of trends (population description) over time by considering time (year) as an explanatory variable not as replicates.

We will test at 5% Type I error (i.e. $\alpha = 0.05$), and show p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

Monitoring of juvenile life history characteristics will occur annually for the duration of the program operations. Testing for change will occur in 5-year intervals. Examination will occur in Imnaha River, Lostine River, Catherine Creek, and the upper Grande Ronde River.

Methods

3.c.1 – *Age-at-emigration* (see 2.b.1) for hatchery production groups will be a standard program description of age at release with validation and potential adjustment from delayed PIT tag detection at Lower Granite Dam. Standard aspect of PTAGIS data query.

3.c.2 - *Size-at-emigration* (see 2.b.2) for hatchery production generated from pre release sampling of 500 fish per raceway.

3.c.3 - Volitional release monitoring of date and diel juvenile life stages and methods for determining relative abundance by life stage is provided in sections 2.b.2 and 1.d.14.

3.c.4 - Migration timing past Lower Granite Dam is described in section 2.b.3

MANAGEMENT OBJECTIVE 4: KEEP IMPACTS OF HATCHERY PROGRAM ON NON-TARGET CHINOOK SALMON POPULATIONS WITHIN ACCEPTABLE LIMITS.

Monitoring and Evaluation Objective 4a. Determine the proportion of naturally spawning fish that are stray hatchery fish (stray composition) in the Minam and Wenaha rivers.

Ho: The proportion of hatchery-origin carcass samples over time (year) in each reference stream is not greater than 10%.
Ha: The proportion of hatchery-origin carcass samples over time (year) in each reference stream is greater than 10%.

Data is generated from the proportion of carcasses recovered that are of hatchery-origin in each reference stream over time. The interest of co-managers is whether the proportion over years is larger than a preset threshold (e.g. 10%). The threshold is based on the Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units (VSP) document (McElhany et al. 2000). Hatchery/natural composition is determined from carcass recoveries during multiple pass extensive area spawning ground surveys.

The t-test for one-sample hypothesis is appropriate. We calculate the sample mean and variance from the proportions over years, and thus calculate test statistic assuming the threshold is true mean.

We will test at 5% Type I error (i.e. $\alpha = 0.05$), and show p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

Monitoring dispersion and impacts of hatchery-produced fish to wild populations is a core monitoring activity that should be continued for the duration of the hatchery production program. Monitoring will occur in the Minam and Wenaha rivers.

Methods
4.a.1 – Spawning Ground Surveys (see section 1.a.2),

4.a.2 – Comprehensive hatchery-origin fish marking (Appendix B).

Monitoring and Evaluation Objective 4b. Determine origin of stray hatchery fish in the Minam and Wenaha rivers.

Descriptive: Proportional characterization of hatchery release group origin straying in reference streams annually.

The key measure described under this objective is identification of the origin of hatchery fish straying into the Minam and Wenaha rivers or other out-of-basin streams. Individual hatchery release groups observed will be summarized as a percentage of the total number of hatchery carcasses recovered in each reference stream during multiple pass extensive area spawning ground surveys.

No statistical testing is required under this objective.

Ideally, this monitoring would occur indefinitely as part of the status monitoring activities in the Minam and Wenaha rivers. Monitoring will occur for the duration of the in-basin hatchery programs and should be reviewed for longer implementation in light of out-of-basin stray occurrence.

Methods

4.b.1 – Fish marking of hatchery release groups to be determined in streams from CWTs and other unique release identifying marks (VIE). Currently all fish released are marked with CWTs. Comprehensive CWT marking may not be required under some circumstances (Marking Approach and Management Needs section). Release group marks are established to quantify group performance to the natal tributary. See experimental unit section for release group size guidelines.

4.b.2 – See 1.a.2 for spawning ground survey methods. Tagged fish are sampled at various commercial, recreational, and escapement fisheries coast wide by sampling agencies. These agencies usually record the sampling area, number caught, percent of catch that was sampled, and related information. This information is called Catch/Sample data and is collected and submitted to the RMPC on a yearly basis by reporting agencies.

4.b.3 – CWT tag extraction and reading is required to determine release group identifiers. This activity will be completed within one year of collection. Tag codes are validated by an independent observer, a third observation and group analysis occurs when tag code discrepancies occur. Results will be uploaded to RMIS data base. The Pacific States Marine Fisheries Commission hosts the Regional Mark Processing Center (RMPC). This office maintains an on-line Regional Mark Information System (RMIS) to facilitate exchange of CWT data between release agencies and the sampling/recovery agencies, and other data users. The CWT database houses information relating to the release, sample, and recovery of coded wire tagged salmonids throughout the Pacific region. These data flow to the RMPC in the form of files sent by magnetic media or electronic transfer, and must meet stringent validation criteria for inclusion in the permanent database. Users of the RMIS application must be familiar with the document: "Specification for Reporting Salmonid Production and CWT Data".

Monitoring and Evaluation Objective 4c. Determine distribution and stray rates of Catherine Creek, Lostine, upper Grande Ronde and Imnaha river hatchery fish.

Descriptive: Annual summarization of non-natal stream recovery locations of hatchery release groups.

Ho: The relative stray rate of an individual release group is equal to other hatchery programs in index monitoring populations.
Ha: The relative stray rate of an individual release group is greater than other hatchery programs

The key measures are distributions and stray rates based on recoveries of CWT fish outside and within subbasin. Stray rate is defined as the cumulative percent of a hatchery release group identified/recovered in spawning populations outside release stream. This descriptive statistic can be partitioned into in-basin and out-of-basin stray rate. It requires the normalization of mark recovery/sampling effort over multiple areas. Alternatively, the mark recovery data can be viewed as stray index for relative comparisons across hatchery programs. In either case this measure should be viewed a minimum estimate given lack of comprehensive sampling throughout the Columbia River basin.

It is important to note that stray rate is not synonymous with stray composition described in 4a. If the null hypothesis is rejected for a NEOH release group in any out-of-basin stream then objective 4a would be expanded to quantify the stray composition from that NEOH release group in that out-of-basin population.

A simple t-test is appropriate because we compare a relative measure of performance for hatchery programs directly over time. Years are replicates.

This monitoring should be conducted over the duration of the hatchery program. Analysis of annual data could occur every five-years given the delayed reporting of CWT recovery data by some programs and reality that repeated observations of high impact would be needed to consider program modification.

Methods

4.c.1 – Fish marking (Appendix B).

4.c.2 – SGS and reporting of CWT/mark recoveries to RMIS (see section 4.b).

4.c.3 – Query RMIS database (see section 4.b).

MANAGEMENT OBJECTIVE 5: RESTORE AND MAINTAIN TREATY RESERVED TRIBAL AND RECREATIONAL FISHERIES.

Co-managers share common goals regarding the Chinook salmon resources of the Imnaha and Grande Ronde subbasins. We desire an adequate escapement to assist population recovery, the conservation of genetic and life history characteristics, and to maximize the harvest of surplus fish. Managers need to know in advance run size and timing to achieve these goals. There are two kinds of forecasts for anadromous fish management: pre-season and in-season. A pre-season forecast is made before mature fish start to arrive at a local management area. Once fish reach a local management area, managers start to monitor the run and collect data about the run. On the basis of these data, an in-season forecast is made. The in-season forecast is updated as new data are available to more precisely estimate run size and timing. This in-season forecast helps managers regulate fisheries that target returning fish. The regulations include opening or closing a fishery in a certain area during a certain time.

Harvest monitoring activities are designed to quantify harvest occurring over the entire life cycle in commercial, sport, and tribal fisheries. Monitoring units specifically supporting NEOH evaluations include: ocean, Columbia River, Snake River, Imnaha River, and Grande Ronde River. Ocean and mainstem Columbia River commercial fisheries are managed through national and international agreements. Ocean harvest regulations are set to minimize harvest of ESA-listed and depressed salmonid stocks. Commercial fishing seasons in the mainstem Columbia River are established by the Columbia River Compact. The Columbia River Compact is comprised of the ODFW and WDFW Commissions. Select area commercial seasons in state waters are established by the regulating state.

The Columbia River Treaty Tribes regulate Treaty Indian ceremonial and subsistence fisheries in the mainstem and tributaries. The ESA listing of Snake River salmon and steelhead has resulted in the Tribe voluntarily structuring Ceremonial and Subsistence (C&S) fisheries to avoid or limit catch of these protected fish. Recreational fisheries for the Columbia River and tributaries are established by the regulating state in cooperation with Tribal co-managers and are authorized under US v. Oregon. All fisheries in the Columbia River are conducted within the Columbia River Fish Management Plan, Federal ESA, and management agreements under US v. Oregon.

Recreational fishing for salmon was closed in Lookingglass Creek and the Imnaha River for over two decades until 2001, when fisheries for hatchery origin Chinook salmon opened. In-tributary recreational harvest allocations and opportunities are defined in the Tribal Resource Management Plan for the Imnaha River subbasin (NPT 2001). This Plan defines allocation of natural and hatchery fish for escapement, broodstock, and harvest. The Plan was adopted by US v. Oregon co-managers as a component of a "stipulated order regulating spring Chinook sliding scale hatchery and harvest management in the Imnaha River". The sliding scale type management plan was previously described in the NEOH Master Plan (Ashe et al 2001). The sliding scale framework supports conservation and recovery Chinook salmon by adjusting management to address demographic and genetic risks to the natural population. The plan allows for ceremonial fisheries at all escapement levels and tribal subsistence recreational fisheries when escapement to the mouth of the Imnaha River is predicted to be greater than 700 fish. The Nez Perce Tribe and the State of Oregon are developing a multi-year tribal management plan that expands the sliding scale framework.

Harvest opportunities are likely to develop in the ensuing years in other streams. Therefore, regulation of harvest seasons, locations, and methods will be managed through an annual review processes among co-managers. Information provided by NEOH M&E from run-size predictors will be used when considering harvest guidelines, regulations, and fisheries proposals. Escapement estimates and preseason run-size predictions and precision will help establish annual sliding scale scenarios.

The precision of the forecast will be considered when establishing harvest allocations. A conservative approach will be pursued to avoid over harvest in both tribal and recreational fisheries. Fisheries are tightly managed by area, time, bag limit, hatchery fish quota, and natural fish incidental catch. The following monitoring and evaluation objectives are designed to support biologically sound in-tributary harvest allocation opportunities.

<u>Monitoring and Evaluation Objective 5a</u>. Develop precise and accurate pre-season hatchery and natural fish escapement predictors.

Descriptive: Annual pre-season escapement forecasts for hatchery and natural (or wild) fish in each tributary.

Of key concern when applying forecast estimates to management actions is accuracy, precision and bias of prediction methods. We describe here the methods currently used to derive predictions, an analysis of the accuracy of past predictions, and a discussion of modifications to refine the methods used in the future.

Development of a run-size predictor will be an ongoing process, in which the predictive function will be upgraded each year with the new information available. This activity will occur for hatchery and natural population segment in all treatment streams and for wild populations in reference streams.

<u>Methods</u>

5.a.1 – Pre-season and in-season forecasts. Initial run predictions are made using smolt stocking numbers from the previous year, redd counts from three years before, adult return numbers by age from the previous year and mean brood year age at return. Natural jack estimates are based on total redd counts from three years prior. Hatchery jack estimates are based on the number of smolts released the previous year and on average return rate. We estimate age 4 and age 5 returns from previous year returns of age 3 and age 4 fish and mean conversion rates developed from mean brood year age at return. Mean conversion rates are recalculated every year using all available data. We can determine how well we have done in the past by comparing projections with actual returns to the river.

In-season adjustments have not been formally made in past years. However, broodstock management strategies at the weir have been modified as a result of differences between predictions and actual collections at the weir. In the future, in-season adjustments to predicted hatchery returns will be made using historical timing of PIT tagged Imnaha River Chinook passing Lower Granite Dam, in-season number of PIT tagged Chinook passing Lower Granite Dam and the proportion of each age class that was tagged. For example, if 10 four year old, PIT tagged, Imnaha River Chinook have passed Lower Granite Dam by the time that 50% of the run would normally have passed, we would expect 20 four year old, PIT tagged, Imnaha River Chinook salmon to pass Lower Granite for the year. If 10% of the release group was PIT tagged then we would expand that 20 fish projection to 200 four year old, Imnaha River Chinook salmon for the season crossing Lower Granite Dam. We can calculate historical conversion rates of PIT tags detected at Lower Granite Dam to PIT tags detected at the Imnaha River weir to determine expected loss for that reach of river and apply that loss to the projections based on Lower Granite PIT tag detections. We expect to implement this entire adjustment for the first time during 2004.

5.a.2 - To evaluate the accuracy of our past predictions (Table 4), we correlated predictions with actual estimated returns. We found a high degree of correlation between predicted and actual return numbers, R=.87 for natural fish, R=.95 for hatchery fish and R=.94 overall (Figure 6). To examine bias, we conducted regression analysis of the predicted number against estimated actual number by origin and for total returns. We have determined that the prediction method, while highly correlated, is biased towards predictions higher than actual returns for naturally produced fish. We found no bias for hatchery fish. We plan to try to develop a correction factor to reduce bias and increase the accuracy of our projections.

Table 4. Predicted and estimated actual returns of hatchery and natural Chinook salmon to the mouth of the Imnaha River.

	Predicted			Estimated Actual Returns		
Year	Natural	Hatchery	Total	Natural	Hatchery	Total
1993	242	826	1068	488	1236	1724
1994	194	417	611	138	173	311
1995	115	327	442	242	190	432
1996	1700	510	2210	338	197	535
1997	397	298	695	152	365	517
1998	147	189	336	332	254	586
1999	434	489	923	290	1277	1567
2000	1045	2256	3301	700	1664	2364
2001	3518	3184	6702	2706	3843	6549
2002	2813	4051	6864	1090	3936	5026

We have examined the degree of bias and have that we sometimes overestimated the number of natural fish, particularly in years 1996 and 2002. For clarification, we use mean age structure of natural fish in the predictor for natural fish and mean age structure of hatchery fish in the predictor for hatchery fish. Therefore, the bias cannot be attributable to use of hatchery age structure for natural fish. We are presently examining causes of bias in the natural fish component. The bias potentially comes from two sources of error: overestimates of age 3 and age 4 fish from prior year and age structure variation. We are looking at the data set to determine where the bias comes from. In addition, we are in the process of examining alternate approaches to predict or adjust the prediction of natural fish in-season. The most promising approaches will be to use PIT tagged fish to adjust the estimates, or adjust based on run strength of natural Chinook at Lower Granite Dam.

5.a.3 - *Forecasting method refinement:* We will explore various approaches retrospectively to determine the best method for future use and examine both pre-season and in-season forecast of return size. We will use a relationship where age-specific adult return size is significantly correlated with out-migrating smolts, returning jacks, and siblings to make pre-season forecasts. The sum of forecasts of all age-specific return sizes will equal total run size forecasted to return.

For in-season forecasts, we will use data updated during the current return season, with daily data from past runs. Updated in-season data include catch, counts of adults passing main-stem dams, and PIT tag data. These data provide information about cumulative return size by during the season. With past daily run data, we can calculate cumulative run proportions per day. If we observe the cumulative return size up to a certain day during the season and also know the cumulative return proportion at the day, we can easily calculate final return size by dividing the observed cumulative return size by the proportion. However, we expect to find variability in the return proportion at a certain day (Hyun 2002). To address variability, we will use all the historical return proportions rather than the mean value of the proportions.

In-season adjustments for natural fish will use mean run timing and current numbers of fish trapped at the weir. In future years, we desire to use PIT tag detections at Lower Granite Dam to adjust natural fish predictions. PIT tagging of Imnaha River natural juvenile emigrants currently focuses on representative tagging of smolts to estimate juvenile survival to Lower Granite Dam and quantify smolt to adult survival rates. Non-representative tagging of fall presmolt emigrants also occurs. Representative tagging of emigrants across all life stages for SAR quantification and estimation of total emigrant abundance to enable run predictions has been proposed but is not currently funded. This would allow us to determine the proportion of natural fish that are PIT tagged and to expand Lower Granite Dam detections to estimate total returns.

In a Bayesian format, we will incorporate pre-season forecast as "prior" into the in-season forecast (Hyun 2002). In-season forecast is the likelihood component and pre-season forecast is the a priori. Based on the resulting posterior predictive density of return size, we will show not only a point estimate of return size but also its confidence interval.

Analysis of data gathered under other monitoring activities will be used to evaluate alternative approaches to predicting run sizes for each harvest area. Predictors to be evaluated include estimated smolt number passing Lower Granite Dam or John Day Dam, estimated number of jacks returning from the same cohort, number of age three fish landed in ocean fisheries, and in-season counts of adult Chinook salmon passing mainstem dams.

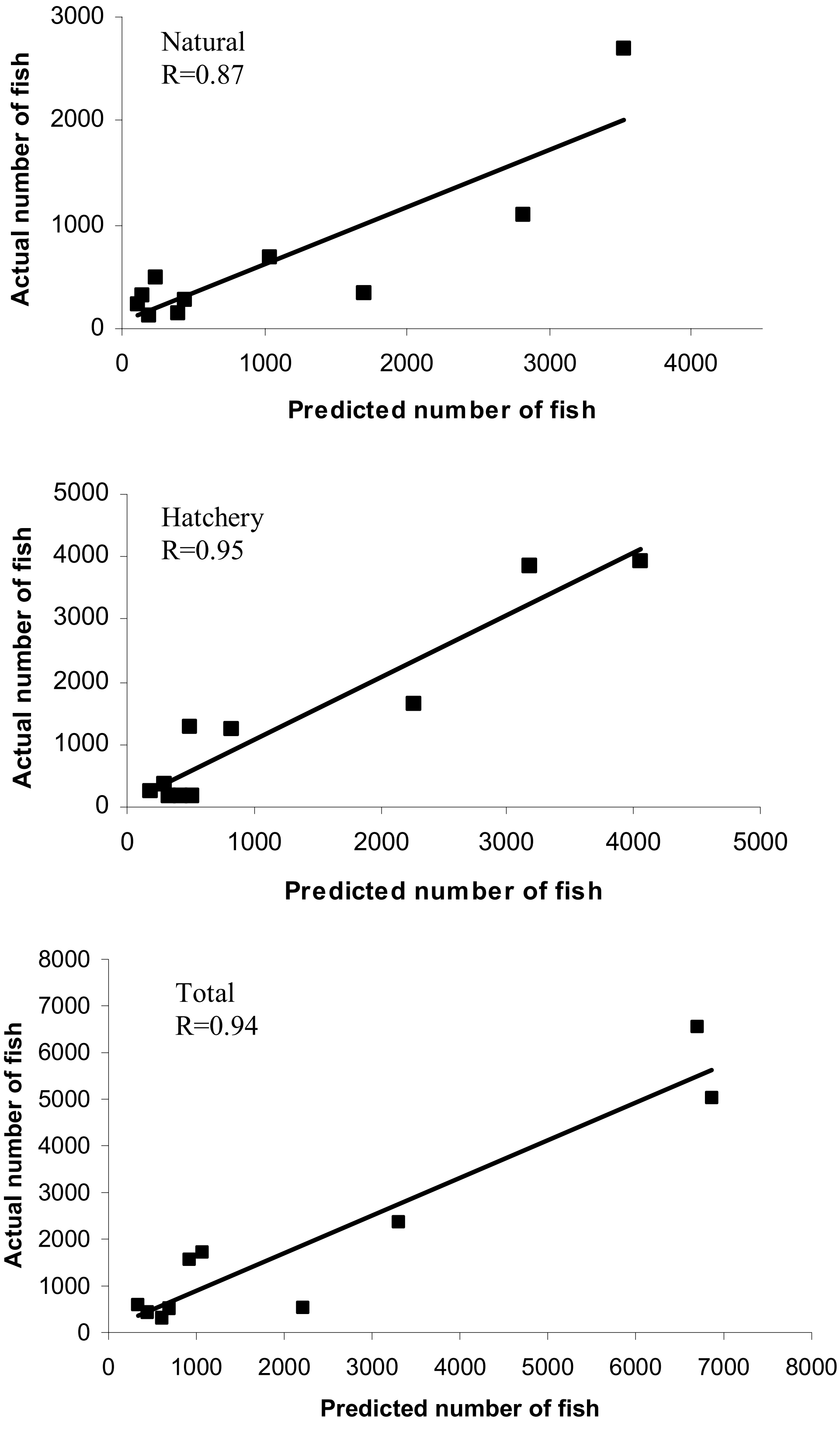


Figure 6. Correlation of predicted and actual Chinook salmon returns to the Imnaha River for natural, hatchery and total returns.

<u>Monitoring and Evaluation Objective 5b</u>. Determine annual tribal and recreational catch, harvest, and effort for hatchery and naturally produced spring Chinook salmon.

Descriptive: Annual estimate of in-tributary harvest.

This monitoring effort will enumerate tribal and sport fisheries by gear type and by fishery area, numbers of fish caught and kept, numbers released, catch per unit effort (CPUE), and other relevant catch information. Methods will include roving creel surveys (pressure counts and interview), check stations (census counts), and post season interviews. Data will be analyzed to determine if certain time, area, or gear restrictions would allow harvest of hatchery Chinook salmon while minimizing capture of natural fish. Biological data and fish origin based on the presence/absence of adipose fin, Visual Implant tag, Coded-Wire-Tag, PIT tag, or other mark types will also be collected. In-season monitoring of the catch composition of hatchery versus natural (dependent upon existence and type of mark) will be conducted so harvest guidelines and constraints can be determined and appropriate regulation modifications undertaken. The management objective of the sampling design is to estimate catch or harvest with a coefficient of variation value of 0.3 for 95% of the sampling time. This CV value assures that we are adequately sampling the fishery.

Surveys will be conducted any time that fishing seasons for Chinook salmon are permitted. Within the Imnaha and Grande Ronde subbasins, there will be more opportunities to harvest excess hatchery-origin fish than natural-origin fish. Harvest experiments are likely to be performed to develop techniques for harvesting hatchery fish with a minimum of disturbance to natural fish. NEOH fish will marked in multiple manners, potentially including some only internally marked and not readily identifiable in the harvest by anglers.

<u>Methods</u>

5.b.1 - Tribal harvest estimation and statistical analysis. The monitoring surveys were developed as a stratified random design to determine weekday versus weekend fishing preference. Information to be collected in the proposed fisheries will include the following: 1) number of fishers, 2) time period engaged in fishing activity, 3) fisher catch per hour (FCPH) for fisher monitoring or harvest per unit effort (HPUE) for fisher interviews, 4) species, 5) number of hatchery or wild/natural Chinook released, and 5) number of hatchery or wild/natural Chinook harvested.

Statistical analysis of creel catch data and the calculation of harvest expansions for each tributary and strata will give a measure of variance, which could then be used to calculate the level of uncertainty for each catch estimate. Calculating the standard deviation and 95% confidence interval for each tributary and strata will produce a upper and lower range to weekly catch harvest estimate per tributary. This approach has been evaluated and implemented based on results from prior tribal fisheries in the Salmon River Basin held in 2001 and 2002.

<u>Creel Survey</u> - Data will be collected by direct observation on specific days selected from a seven-day timeframe (Sunday-Saturday). For those tributaries identified for this method, data will be collated and entered into a spreadsheet by hour increments contained in a 24 h sampling period that represents the 24 h fishing. The monitors will survey an 8 h selected randomly from

the 24 h fishing period. The sampling days will include two days during the week and one weekend day for that seven-day time period.

Mean fisher catch per hour (FCPH) expanded by fisher effort data will be used to derive weekday and weekend estimated catch. Weekday and weekend catch will be summed to give total weekly catch and the weekly fisher catch per hour (computed by dividing weekly catch by weekly fisher effort). The expansion will produce a harvest estimate for that specific fishing location and season duration. The results generated from monitoring are to be used to evaluate the statistical effectiveness of the sampling design.

From the sampling data the computer spreadsheet will generate an expansion base on the following equation (Sharma 2003):

$$\hat{C}_{S,t} = \hat{N}_{s,t} \times \frac{\sum_{i=1}^{x} \frac{C_{i,a}}{n_{obs}}}{x} \times H_f \times A_f$$

or ,

$$\hat{C}_{S,t} = \hat{N}_{s,t} \times FCPH \times H_f \times A_f$$

Where $\hat{C}$ is the catch in area (*S*) over time (*t*),

N (hat) = estimate of the number of fishers in area (*s*), and time (*t*),
C = the catch observed in area *a* (a subset of area *S*) and time *i* (for the observed number of fishers, *n*) over the number of *i*'s (*x*) sampled (average catch per hour),
FCPH = the average observed fisher catch per hour,
H = the number of hours the fishery is open, and
A = the proportion of the fishery area sampled (constant 20% of the area sampled).

The task is to estimate confidence intervals (CI), precision (indicator of data quality), and variance (indicator of monitoring effort) in catch for tributary fisheries that use data produced from the creel survey collection method. Random stratified observations based on fishery effort will be used to produce weekly catch expansions.

Comparison of the CI, precision, and variance values for weekly expansions are used to determine where majority of variability in the monitoring of catch occurs. The following statistical measures for each respective fishery that uses the creel survey method will be calculated:

a. The sample mean is sum of the catch observed in a specific area and time (for the observed number of fishers) over the number of fishers sampled (average catch per hour) for the number of hours the fishery is opened.
b. The estimate of standard error (SE) of the sample mean is used to measure the level of precision for an estimate (assuming normality of the catch data). Our attempt is to produce a SE value that is equal to or less than 20% of the estimate, to ensure that the

95% confidence intervals surrounding the estimate is kept within a statistically desirable range.

c. The range, sample variance (s^2), and sample standard deviation (SD), are measures of dispersion of data that describe sampling variation. These statistical procedures characterize the spread of sample measurements about the sample mean (used to express central tendency). The variability of the sample mean is denoted by $Var(\hat{C})$ above (no variance associated with the estimate of the number of fishers in specified area and time, the number of hours the fishery is open, and the proportion of the fishery area sampled).

In-season Reporting - To compensate for our inability to conduct creel surveys for each tributary fishery, we will institute an in-season interview data collection method to derive a ratio harvest estimate. This approach is also designed to ground-truth the creel survey expansion estimates for those particular tributaries using creel survey. The proportion of fishers not contacted in the interview method will be expanded by the fisher effort as enumerated by the creel survey. Comparison between the two data collection methods is being implemented to help identify a fishing efficiency rate that could be applied to interview data (i.e., expand the interview ratio estimate by some established factor).

The harvest monitors will routinely conduct interviews with the tribal fishers and submit the data collection sheets for tabulation in the spreadsheet on a weekly basis. This can be facilitated through direct contact with tribal fishers by harvest monitors assigned to a specific tributary for creel survey duties. The interview will be documented on a weekly basis to avoid counting the same fish over in subsequent interviews.

From the interview data, the calculation of HPUE will be based on the total-ratio estimator as described by the following steps:

Total-ratio estimator: HPUE=h/e,

$$\hat{R}_2 = \frac{\sum_{i=1}^{n} h_i}{\sum_{i=1}^{n} e_i}$$

$\sum_{i=1}^{n} h_i$ = sum fish harvested per fisher (h_i) over all fishers interviewed (n).

$\sum_{i=1}^{n} e_i$ = sum hours fished per fisher (e_i) over all fishers interviewed (n).

Catch is generated for the unsampled fishers using the equation below:

$$\hat{C}_{s,t} = \hat{R}_2 \times H_f \times \hat{N}_{S,t}$$

Where $\hat{C}$ is the catch in area (S) over time (t),

R = the catch efficiency per fisher hour
H = the number of hours fishery was open in area S
N = the number of unsampled fishers in area (S) at time (t)

The task is to estimate confidence intervals (CI), precision (indicator of data quality), and variance (indicator of monitoring effort) in catch for the SRB tributary fisheries that use data produced from the inseason interview collection method. The purpose is to determine weekly catch expansions.

Comparison of the CI, precision, and variance values for weekly expansions are used to determine where majority of variability in the monitoring of catch occurs. The following statistical measures will be calculated for the harvest estimates produced from the inseason interview method:

d. The sample mean is sum of the catch efficiency rate observed in a specific area and time (for the observed number of fishers) multiplied by the number of unsampled fishers for the number hours the fishery is opened.
e. The estimate of standard error (SE) of the sample mean is used to measure the level of precision for an estimate (assuming normality of the catch data). Our attempt is to produce a SE value that is equal to or less than 20% of the estimate, to ensure that the 95% confidence intervals surrounding the estimate is kept within a statistically desirable range.
f. The range, sample variance (s^2), and sample standard deviation (SD), are measures of dispersion of data that describe sampling variation. These statistical procedures characterize the spread of sample measurements about the sample mean (used to express central tendency). The variability of the sample mean is denoted by $Var(\hat{C}_{S,t})$ above (variance for the catch is dependent on the variance of R multiplied by the number of hours the fishery is open and the number of unsampled fishers).

An assumption is that the majority of fishers will be contacted and a ratio estimate of total harvest over the duration of the fishing season will be produced. Differences in daily fishing effort acts as a self-weighting factor for harvest estimates produced by this method. The harvest data contributed by individual fishers used in the total-ratio estimator are weighted by the amount of fishing effort expended, and is the appropriate estimator to use for calculation of total harvest when completed trip data is used.

5.b.2 – Sport harvest estimation and statistical analysis. Surveys will be stratified by weekends and weekdays and AM and PM. AM surveys will be conducted 0700 – 1400 and PM surveys will be 1400 – 2100). Each clerk will conduct effort counts every two hours starting at either 0700 (0700, 0900, 1100, and 1300) or 0800 (0800, 1000, and 1200) for AM surveys and 1400 (1400, 1600, 1800, and 2000) or 1500 (1500, 1700, and 1900) for PM surveys. Anglers will be interviewed before, after, and between effort counts. New survey forms will be used on each sample day. Interview data will be recorded on the Angler Interview Form and any fish that are checked will be recorded on the Creel Survey Data Form. Snouts will be taken if the angler gives us permission to do so. Survey days were selected semi-randomly with adjustments made to have surveys in two or three day blocks and to limit number of surveys to four days during any Sunday through Saturday work week. In-season estimates will be made weekly to assure we are not exceeding planned catch of wild or hatchery fish.

Estimates of angler effort, catch (fish landed), and harvest (fish kept) were calculated using methods described by Scheaffer et al. (1979) for stratified cluster sampling.

Angler hours were estimated for each stratum as follows:

$$\bar{y} = \frac{\sum yi}{\sum mi},$$

where: $\bar{y}$ = mean number of anglers observed during counts in a stratum;
mi = number of counts made during the ith sample day; and,
yi = total of all counts made on the ith sample day.

Total angler hours (*T*) was estimated for each stratum by:

$$T = M\bar{y},$$

where: *M* = total daylight hours in the stratum.

Variance of total angler hours (*V(T)*) was estimated by:

$$V(T) = \frac{N}{n}^{2}\left(\frac{N-n}{N}\right)\left(\frac{\sum(yi-\bar{y}mi)^{2}}{n-1}\right),$$

where: *N* = total days in the stratum;
n = number of days sampled; and,
other variables as described above.

A bound on the error of estimation (bound) was then calculated to approximate a 95% confidence interval. A bound is approximately equal to a 95% confidence interval if data have a normal probability distribution and at least a 75% confidence interval regardless of the probability distribution (Scheaffer et al. 1979).

The bound on T was calculated as +/- $2\sqrt{V(T)}$.

Total angler hours for the season was estimated as:

$$Tst = \sum Ti,$$

where: *Tst* = total angler hours for the season and
Ti = angler hours in stratum i.

Variance of *Tst* = *V(Tst)* = $\sum V(Ti)$ and a bound was calculated as +/- $2\sqrt{V(Tst)}$.

Mean catch rates and harvest rates (fish/angler hour) were estimated by:

$$\bar{x} = \frac{\sum wixi}{\sum wi},$$

where: $\bar{x}$ = mean catch or harvest rate for the stratum;
xi = catch rate or harvest rate for the ith party interviewed; and,
wi = total angler hours expended by the ith party when interviewed.

Variance of catch rates was estimated by:

$$V(\bar{x}) = \left(\frac{1}{n}\right)\frac{\sum wi(xi - \bar{x})^2}{\sum wi},$$

where: $V(\bar{x})$ = variance of mean catch or harvest rate;
n = number of parties interviewed in the stratum; and,
other variables ad described above.

Mean catch rate for the season was estimated by:

$$\bar{x}st = \frac{1}{\sum ni}\sum ni\bar{x}i,$$

where: $\bar{x}st$ = mean catch rate for the season;
ni = number of parties interviewed in stratum i; and,
$\bar{x}i$ = mean catch rate or harvest rate for stratum i.

Total catch or harvest (C) for each stratum was estimated by:

$$C = T\bar{x},$$

where: $\bar{x}$ = mean catch or harvest rate and
T = total angler hours.

Variance of total catch or harvest was estimated as described by Goodman (1960) with the exception that we did not attempt to estimate a covariance between angler effort and catch rates. Variance of total catch and harvest (V(C)) was estimated as follows:

$$V(C) = M^2\left(\bar{x}^2(V(\bar{y})) + \bar{y}^2(V(\bar{x}))\right),$$

where: M = total daylight hours in the stratum;
$\bar{x}$ = mean catch or harvest rate for the stratum;
$\bar{y}$ = mean of all counts in the stratum;
$V(\bar{x})$ = variance of catch rate; and
$V(\bar{y})$ = variance of counts.

Bound on catch and harvest estimates was calculated as +/- $2\sqrt{V(C)}$. Catch and harvest estimates and their variances were summed to estimate totals and bounds for the season.

5.b.3 – Biological information will be collected for each fish observed during tribal and sport creel survey activities. Fork length (0.5 cm) will be recorded, scales may be collected on a sub-sample of fish (willing anglers), sex determined from external characteristics, and externally detectable marks recorded. Snouts from CWT positive fish will be collected from willing anglers.

5.b.4 – Harvest rates (percentage of population harvested) in the ocean and Columbia River are already estimated for Snake River spring Chinook salmon each year by the Pacific Salmon Commission. Groups that reach the ocean as juveniles on different dates often show some difference in the spatial distribution of ocean harvest. Because there are location and time closures in ocean commercial fisheries, the pattern of ocean distribution for a stock can strongly influence the rate at which it is harvested. Ocean recoveries of CWT's are reported to the Pacific States Marine Fisheries Commission, so we will obtain the data on actual and expanded recoveries in the ocean from the Regional Mark Information System (RMIS).

MANAGEMENT OBJECTIVE 6: OPERATE THE HATCHERY PROGRAMS TO ACHIEVE OPTIMAL PRODUCTION EFFECTIVENESS WHILE MEETING PRIORITY MANAGEMENT OBJECTIVES FOR NATURAL PRODUCTION ENHANCEMENT, DIVERSITY, HARVEST, IMPACTS TO NON-TARGET POPULATIONS.

Monitoring and Evaluation Objective 6a. Determine the influence of production strategy on smolt emigration characteristics, smolt-to-adult survival, and age structure for each experimental unit within production groups.

Ho: There is no difference in egg to smolt (release) survival rate between different hatchery production experimental units within a production group over time.
Ho: There is a significant difference in egg to smolt (release) survival rate between different hatchery production experimental units within a production group over time.

Ho: There is no difference in survival rate of smolts from release to Lower Granite Dam between different hatchery production experimental units within a production group over time.
Ha: There is a significant difference in survival rate of smolts from the release to Lower Granite Dam between different hatchery production experimental units within a production group over time.

Ho: There is no difference in juvenile emigration-timing over time between different hatchery production experimental units within a production group over time.
Ha: There is a significant difference over time in juvenile emigration-timing between different hatchery production experimental units within a production group over time.

Ho: There is no difference in smolt-to-adult return rate between different hatchery production experimental units within a production group over time.
Ha: There is a significant difference in smolt-to-adult return rate between different hatchery production experimental units within a production group over time.

Ho: There is no difference in adult run-timing over time between different hatchery production experimental units within a production group over time.
Ha: There is a significant difference over time in adult run-timing between different hatchery production experimental units within a production group over time.

Ho: There is no difference in adult age-at-return structure over time between different hatchery production experimental units within a production group over time.
Ha: There is a significant difference over time in adult age-at-return structure between different hatchery production experimental units within a production group over time.

Descriptive: In the absence of multiple experimental units within a production group, characterization of smolt emigration characteristics, smolt-to-adult survival rate, and age structure should be determined for the production group as a whole.

The focus of the objective is the relative/comparative performance of different hatchery production approaches to one another in order to maximize performance of the hatchery product through an adaptive management process. Comparative testing of hatchery production to natural production is described under monitoring and evaluation objectives 1 –3. Performance measures to be tested between treatment groups (experimental units) are egg-to-smolt survival, juvenile survival to Lower Granite Dam, mainstem arrival timing, smolt-to-adult return rate, age-at-return, and adult run-timing. Quantification of these performance measures will use standard PIT Tag and CWT methods.

Hatchery production approaches for each experimental unit will change over time. A maximum of three (typically two) treatment groups will be tested within a production group at one time. Generally, each suite/pair treatments will be replicated for 5 years. The current best hatchery practices approach (preferred production strategy will serve as the "control" to which alternative approaches are measured. The process for selecting production strategies to be tested follows the LSRCP Monitoring and Evaluation Guidelines (MEG). The MEG process involves; proposal development based on critical uncertainties relative to documented deviations from program goals and/or regional high priorities, peer review of proposal design, and coordinating implementation with ongoing evaluations. Currently, comparative performance is being tested on: conventional production smolts vs captive broodstock production smolts within the Lostine River, Catherine Creek, and Upper Grande Ronde production groups. Juvenile growth profile testing is currently being reviewed for implementation in the Imnaha production group due to documented differences in age-at-return structure between hatchery-origin and natural-origin returns.

With a continuous variable such as survival rate for data set, the paired t-test is appropriate where time (year) plays a role of 'pair.' With a categorical variable such as age structure, two-factor ANOVA test is appropriate, where two factors are type (treatment 1 and treatment 2) and the category, and time (year) plays a role of 'replicate' for five year periods. Multi-factor ANOVA (i.e. a multiple regression model) or a GLM (generalized linear model) will be efficient when we compare type (treatment and control) over time with all available smolt characteristics.

Comparative testing of alternative production strategies will continue over the duration of the NEOH program. Implementation supports a scientifically defensible approach adaptive refinement of hatchery production strategies but is not an essential under standardized/stable production strategies. Testing would be conducted within the Imnaha River, Lostine River, Catherine Creek, and Upper Grande Ronde production groups.

Methods

6.a.1 – *Egg-to-smolt survival* is based on the number of smolts released as a percentage of total eggs from an experimental production unit. Egg abundance will be determined by hatchery specific production monitoring techniques (direct counts at shocking or volumetric estimates). Number of smolts released will be determined from fish counts at time of tagging (mass marking) adjusted for post- marking mortality counts.

6.a.2 – *Release to Lower Granite Dam survival* via PIT tags (see section 1.d.5).

6.a.3 - *Mainstem Arrival-timing* via PIT tags (see section 2.b.3).

6.a.4 - *Smolt-to-adult survival rate* via CWTs (see section 1.e.3 and Experimental Production Unit section).

6.a.5 - *Age-at-return* based on known age as determined from CWT and differential mark identification (see section 1.a.6).

6.a.6 – *Adult run-timing* (see section 3.b.2) based on identification of marks for each experimental unit at weirs and PIT tag interrogation sites (Lower Granite Dam and Imnaha River).

6.a.7 - Performance of the captive broodstocks will be compared on several different levels and at several key points in the life cycle of the salmon. The main level of performance deals with the offspring of the two programs. The captive broodstock are spawned in the captive broodstock building at Bonneville Fish Hatchery and the eggs are first incubated at Oxbow Fish Hatchery (OFH) before being transferred at the eyed stage to Irrigon Fish Hatchery (IFH), where they are hatched and initially ponded. The conventional broodstock are spawned at Lookingglass Fish Hatchery (LFH) and incubated at LFH, IFH and/or OFH. Fish from both programs are transferred to LFH in April for rearing to smolt the following spring. The fish are differentially marked and released to complete their life cycles in nature.

Key evaluation points may be divided into phases of the life cycle of the salmon and these programs. During the *Adult Phase* we collect gametes and may compare size of adult fish, fecundity, egg size and fertility. The *F_1 Generation Phase* begins at fertilization of eggs from captive broodstock fish and ends when the resulting fish die. This phase is composed of the <u>incubation</u>, <u>juvenile rearing</u>, <u>smolt release</u>, <u>post-smolt growth</u>, <u>maturation</u> and <u>spawning</u> periods. Many of the standard hatchery evaluation variables are used to assess performance. Important variables include: egg survival, hatching time, fry survival, growth rates, condition, size distribution, fry-smolt survival, smolt outmigration performance, smolt-to-adult survival, run timing, age structure at return, size-at-age, sex ratios, pre-spawn survival in nature, spawning distribution in nature, spawning success and straying. The *F_2 Generation Phase* begins once embryos resulting from F_1 Generation fish are formed and ends when fish from these embryos die. This phase is composed of the <u>pre-smolt</u>, <u>smolt</u>, <u>post-smolt growth</u>, <u>adult return</u> and <u>spawning</u> periods. During this period we measure variables in the natural environment to assess the natural production performance of captive fish reproducing in nature. Variables include egg-to-fry survival, egg-to-smolt survival, juvenile tributary migration patterns, growth rates, parr and smolt production, smolt migration patterns, smolt-to-adult survival, run timing, age structure at return, size and age at maturation, sex ratios, pre-spawn survival in nature, spawning distribution in nature, spawning success, straying and productivity (progeny to parent ratios).

We will also examine the overall effectiveness of that captive broodstock program vs. a conventional program. We will compare the ability of each type of program to increase and sustain population levels. We will also evaluate the benefits and risks of each type of program to develop recommendations about when each type of program should be used. An increase in the number of wild spawning fish above that which would have been produced without a supplementation program (due to the F_2 generation) will be the final measure of success for these programs.

Lastly, we can evaluate the performance of each program and the hatchery-reared fish, as a unit, vs. naturally-reared fish as describe in Management Objectives 1-3. We compare egg survival, fry survival, growth rates, condition, size distribution, fry-smolt survival, smolt outmigration performance, smolt-to-adult survival, run timing, spawn timing, age structure at return, size-at-age, sex ratios, pre-spawn survival in nature, spawning distribution in nature, spawning success and straying.

<u>Monitoring and Evaluation Objective 6b</u>. Compare management plan objectives and actions with program outcomes to determine plan feasibility and effectiveness.

Ho: Estimate of escapement is not greater than the threshold (e.g. escapement goal) pre-set by managers.
Ha: Estimate of escapement is greater than the threshold (e.g. escapement goal) pre-set by managers.

Ho: Hatchery smolt-to-adult return rate are equal to LSRCP/NEOH planning criteria (0.65).
Ha: Hatchery SAR smolt-to-adult return rate are significantly different that LSRCP/NEOH planning criteria (0.65).

Descriptive: Weir effectiveness for manipulating hatchery natural composition in support of sliding scale prescribed ratios (within 10%).

Descriptive: Weir efficiencies over time.

Descriptive: Abundance, age-structure, and hatchery:natural composition of broodstock collected annually.

Descriptive: Ability to meet representative broodstock collection based on weir efficiency, run forecast and timing estimates.

Descriptive: Effectiveness of harvest management in support of sliding scale escapement objectives and attainment of broodstock quotas.

The key measure is adult abundance partitioned into spawners, harvest, and broodstock components by origin relative to management thresholds. We will determine whether the escapement estimate is larger than the escapement goal pre-set by managers. Descriptive measures will be expressed in terms of basic summary statistics.

The t-test for one-sample hypothesis is appropriate. We calculate the sample mean and variance from the estimates over years, and thus calculate test statistic assuming the threshold is true mean.

We will test at 5% Type I error (i.e. $\alpha = 0.05$), and show p-value of test statistic. If the p-value is less than the level of Type I error, we will reject null hypothesis.

Implementation of this objective will be continual over the duration of the NEOH program. Activities will occur in all treatment streams (Imnaha River, Lostine River, Catherine Creek, Upper Grande Ronde River, and Lookingglass Creek).

Methods

6.b.1 – Adult abundance to tributary partitioned by run-reconstruction attributes (see section 1.a.1).

6.b.2 - Smolt-to-adult survival rate for hatchery and natural-origin fish (see section 1.e.3).

Monitoring and Evaluation Objective 6c. Determine disease agents or pathogen presence and prevalence in supplemented populations and compare with pre-supplemented presence and prevalence.

Ho: Disease agent or pathogen history (presence/absence) is equal in natural and hatchery production groups.
Ha: Disease agent or pathogen presence is higher in hatchery production groups than the natural population.

Ho: Frequency of disease outbreaks is equal between natural and hatchery production groups.
Ha: Frequency of disease outbreaks is higher in hatchery production groups relative to natural population segment.

Ho: Frequency of disease outbreaks in hatchery production groups is stable over time.
Ha: Frequency of disease outbreaks in hatchery production groups is increasing over time.

Key measures related to fish health focus on the prevalence of infectious diseases in terms of pathogen presence within a population and the frequency of disease outbreaks. The test comparisons are between hatchery and natural production segments within a population over time, including pre and post-supplementation periods in select streams.

Releasing hatchery fish into the natural environment could potentially increase physiological stress, introduce pathogens or trigger outbreaks of existing pathogens in natural fish. There is little evidence to suggest that widespread transmission of disease occurs from infected hatchery fish. However, neither has there been much effort directed toward detecting such transmission. Disease and parasites in hatchery fish are well documented. Yet little is known about the epidemiology of pathogens and parasites in natural fishes as they relate to hatchery releases. Regardless of measures taken to control pathogens, hatcheries release some fish infected with pathogens and parasites. It is important to note that for the most part disease agents originally are introduced from the fish in the natural environment to hatchery fish. Thus fish pathogens and diseases in hatchery fish have come from fish reared in the natural environment. This makes it difficult to study the effect of hatchery fish on natural populations unless there is historical data to show what agents are already present. Disease agent transmission can go either way: wild to hatchery or hatchery to wild.

All sampling, diagnostic, and statistical analyses will conform if possible with the Integrated Hatchery Operations Team (IHOT) and the Pacific Northwest Fish Health Protection Committee. All monitoring will be consistent with the ODFW fish health policy and the native fish conservation policy. Fish health sampling and monitoring will be conducted under supervision of a fish health specialist, and processed at a qualified fish disease laboratory. Analysis of samples will follow standard protocols defined in the latest edition of the American Fisheries Society "Fish Health Blue Book" (Procedures for the Detection and Identification of Certain Fish Pathogens).

Methods

6.c.1 - Detailed fish health sampling of hatchery production groups is outlined annually in the AOP (LSRCP 2003). Fish that are removed from rearing facilities because they are dead or moribund will be temporarily frozen and examined monthly for fish pathogens. Routine health examinations will be conducted annually on 60 grab-sampled fish before release at each facility. In addition a minimum of 60 spawning adults per stock (if available) and available adult mortality will be tested as per AOP guidelines. Adult sampling will include naturally produced fish that will help determine pathogen prevalence among those fish.

6.c.2 - Determining the frequency of common fish pathogen presence and virulence among natural Chinook salmon in NEOH treatment streams will be conducted. Sampling to detect diseases in natural juveniles will be conducted when possible from natural Chinook screw trap mortalities. A sample of 60 wild juvenile Chinook salmon, pooled across sampling sites within a stream, will be killed to screen for the presence of fish pathogens and parasites. Separate samples will be taken in the spring and fall. These sampling plans presume that Chinook salmon are sufficiently abundant to justify sacrificing the number required for disease sampling. Spawned carcasses of naturally-produced adults will be sampled if high pathogen levels are detected among hatchery spawners. Pathogen testing would be the same as for hatchery fish.

Hatchery fish health monitoring is much easier since dead and dying fish are available for examination. In the wild moribund and fresh-dead fish are most likely soon removed due to predation and scavenging. In the wild typically only large-scale juvenile loss and increased adult mortality become more visible to alert people to a problem. The bottom line is that because of the ease of testing hatchery fish (bias) there would be more pathogens and possibly diseases found in hatchery fish. If a disease outbreak is detected, increase sampling intensity to determine its prevalence and full impact on hatchery and natural fish. Localized and intensive disease monitoring will be implemented when significant disease outbreaks occur among natural populations in treatment streams. Standard necropsy, pathogen sampling, and data reporting procedures would be followed. Sampling in reference stream populations would also occur to help identify contributing factors. Environmental parameters such as temperature and dissolved oxygen will be measured where mortality is observed, to determine if the disease may be stress-mediated.

MANAGEMENT OBJECTIVE 7: UNDERSTAND THE CURRENT STATUS AND TRENDS OF CHINOOK SALMON NATURAL POPULATIONS AND THEIR HABITATS IN THE IMNAHA AND GRANDE RONDE RIVER SUBBASINS.

Stock status and performance can be evaluated only with respect to the properties of the natural environment in which the population is found. We will characterize abiotic features of stream habitat and its use by aquatic organisms, specifically Chinook salmon. Habitat features influence the distribution and productivity of populations and sometimes serve as limiting factors. The sampling conducted under this objective will help quantifying the type and availability of habitat features that juvenile and adult Chinook salmon use. Temperature, flow, and substrate are environmental variables that are known to influence Chinook salmon. They will be used in analyses of cause-effect relationships. Understanding habitat use and influence will allow co-managers to make recommendations regarding specific habitat protection and restoration measures in relation to stock status and NEOH operations.

Monitoring and Evaluation Objective 7a. Determine the status and trends of Chinook salmon and habitat in the Imnaha and Grande Ronde subbasins.

Descriptive: Characterization of physical habitat condition throughout each subbasin and trend over time.

Descriptive: Characterization of water temperature profiles for each subbasin and key areas within each treatment and reference stream (including in-hatchery temperatures).

Descriptive: Characterization of stream flow profiles for each subbasin and key areas within each treatment and reference stream (including stream reaches impacted by hatchery facilities).

We will implement the Environmental Monitoring and Assessment Program (EMAP) sampling framework, a statistically based and spatially explicit sampling design to quantify status and trends in stream and riparian habitats. Fifty spatially balanced, randomly selected reaches will be sampled for juvenile salmonids and stream and riparian condition in the Imnaha and Grande Ronde subbasins from late June through September annually.

Sampling domains and site selection: In each subbasin, we will refine the sampling universe for habitat and juvenile surveys based on current distribution maps. The sampling domain will be defined at the upper ends of watersheds by perennial streams and at the lower end by the capability of field crews to snorkel the sample reach.

Juvenile salmonids will be inventoried at all sites within the summer rearing distribution of juvenile *O. mykiss* and Chinook salmon in snorkelable streams below known barriers to upstream migration. Sample sites will be derived from the 1:100k EPA River Reach file. To balance the needs of status (more random sites) and trend (more repeat sites) monitoring, we will implement a rotating panel design in the Columbia Plateau based on recommendations from the EPA EMAP Design Group. The 50 sites drawn on an annual basis for each subbasin will be assigned to the rotating panel design as follows:

- 3 panels with different repeat intervals
- 17 of the sites will be sampled every year
- 16 sites will be allocated to a 4 year rotating panel (sites visited once every 4 years on a staggered basis)
- 17 sites will be new sites each year

With this sampling strategy, 50 sites will be drawn the first year and 33 new sites will be drawn in subsequent years because 17 of the originally drawn sites will be repeated each year. There is nothing "magical" about 50 as precision increases gradually with increase in sample size. For the most part, we want a good estimate of the variance of our target population. Small sample sizes give poor estimates of the variance, and with small samples, random draws can be quite a bit off from the actual population's characteristics (mean, variance, median...). Fifty is a rule of thumb to get a reasonably good picture. Another reasonably good rule of thumb is that doubling precision requires a four-fold increase in sample size. So if you get a particular precision at 50 samples, you'd need 200 samples to double precision. Over the first 3 years of the study, co-managers will evaluate the influence of sample size on meeting/not-meeting/exceeding our target precision levels and make recommendations for adjusting the sample size accordingly. Without the data this survey will provide it is extremely difficult to conduct the appropriate power analysis. Experience on coastal watersheds has demonstrated that a target sample size of 50 sites will meet out precision targets for habitat and juvenile sampling.

Once annual sample sites are drawn, the site is assigned to the river reach file based on site coordinates. A Geographic Information System (GIS) incorporating a 1:100,000 digital stream network is used to insure an unbiased and spatially balanced selection of sample sites across each subbasin. The GIS site selection process provides the geographic coordinates (i.e. latitude and longitude) of each of the candidate sites. We then produce topographic maps showing the location of each sample point. Field crews use a handheld Global Positioning System to find the approximate location of the EMAP selected sample point, and then establish 1 km long survey reaches that encompass the sample point.

Methods

7.a.1 - Habitat and Riparian Survey Methodology: Channel habitat and riparian surveys will be conducted as described by Moore et al. (1997) with some modifications. Modifications include: survey lengths of 500-1000 m and measurement of all habitat unit lengths and widths (as opposed to estimation). Survey teams will collect field data based on stream, reach, and channel unit characteristics. Each field crew is comprised of two people with each member responsible for specific tasks. The "Estimator" will focus on the identification of channel unit characteristics. The "Numerator" will focus on the counts and relative distribution of several unit attributes and will verify the length and width estimates for a subset of units. The "Estimator" and "Numerator" share the responsibility for describing reach characteristics, riparian conditions, identifying habitat unit types, and for quantifying the amount of large woody debris.

To quantify within-season habitat variation and differences in estimates between survey crews, ten percent of the sites will be resampled with a separate two-person crew. Repeat surveys will be a randomly selected sub-sample from each subbasin and each survey crew. Variation in survey location was assumed minimal because survey starting and ending points were marked in the field. The precision of individual metrics will be calculated using the mean variance of the resurveyed streams “Noise” and the overall variance encountered in the habitat surveys “Signal”. Three measures of precision are calculated, the standard deviation of the repeat surveys SDrep, the coefficient of variation of the repeat surveys (CVrep), and the signal to noise ratio (S:N). S:N ratios of < 2 can lead to distorted estimates of distributions and limit regression and correlation analysis. S:N ratios > 10 have insignificant error caused by field measurements and short term habitat fluctuations (Kauffman et al. 1999).

Habitat conditions in each subbasin will be described using a series of cumulative distributions of frequency (CDF). The variables described are indicators of habitat structure, sediment supply and quality, riparian forest connectivity and health, and in-stream habitat complexity. The specific attributes include but are not constrained to:

Density of woody debris pieces (> 3 m length, >0.15 m diameter)
Density of woody debris volume (> 3 m length, >0.15 m diameter)
Density of key woody debris pieces (>10 m length, >0.6 m diameter)
Density of wood jams (groupings of more than 4 wood pieces)
Density of deep pools (pools >1 m in depth)
Percent pool area
Density of riparian conifers (>0.5 m DBH) within 30 m of the stream channel
Percent of channel shading (percent of 180 degrees)
Percent of substrate area with fine sediments (<2 mm) in riffle units
Percent of substrate area with gravel (2-64 mm) in riffle units

While these attributes do not describe all of the conditions necessary for high quality salmonid habitat, they do describe important attributes of habitat structure within and adjacent to the stream channel. The attributes are also indicative of streamside and upland processes. The median and first and third quartiles will be used to describe the range and central tendencies of the frequency distributions of the key habitat attributes used in the analysis of current habitat conditions (Zar 1984). Frequency distributions will be tested to determine if significant differences ($p<0.05$) exist between subbasins for each habitat attribute (Thom et al. 2000).

7.a.2 - Stream temperature can be a limiting factor in the behavior, ecology, and survival of salmonids. Recent data indicates that both adult and juvenile salmonids may utilize thermally moderated temperature zones to escape non-preferred or even lethal temperatures. We propose to characterize and monitor water temperature zones in critical migration, spawning, and rearing habitat in the Imnaha and Grande Ronde subbasins. Water temperatures outside preferred zones may limit juvenile production and preclude adult passage. Thermographs will be continuously operated in-river at all hatchery facility sites; in migration, rearing, and spawning trend areas in treatment and reference stream; and probabilistically located via EMAP in other areas. Areas sampled probabilistically will be monitored for one-year intervals. This data will e utilized to formulate 7 day moving means of daily maximums, values which are applicable to stream temperature criteria developed by DEQ, EPA, and USFS.

7.a.3 - Flow regime is a fundamental factor for predicting how restoration projects will affect physical conditions in the stream. Collecting baseline flow data over the long term is important for understanding the hydrologic response of the watershed as a result of restoration activity and is important for interpreting data collected on other physical parameters. An index of flow is needed for each stream surveyed so that differences in flow between years can be incorporated into the analysis of factors affecting fish densities. The index of flow may either be the daily estimates of flow obtained from USGS gauges, or gage height readings at a standard location with consistent cross-section features. In streams where gauges are used, stream discharge will be measured across a range of flow conditions to develop a discharge to gauge height relationship.

Monitoring and Evaluation Objective 7b. Describe status and trends in juvenile abundance at the population and subbasin scales in the Imnaha and Grande Ronde subbasins.

Descriptive: Characterize parr densities over time for the Imnaha and Grande subbasins.

Descriptive: Characterize smolt production over time in index production areas.

Key measures are parr densities and juvenile emigrant abundance. Co-managers will conduct snorkel surveys using EMAP protocols as described in 7a for subbasin-wide assessment. Monitoring of juvenile emigration will occur continually over time by emigrant trapping in key production streams. EMAP protocols could be applied.

.

Methods

7.b.1 - Juvenile Salmonid Survey Methodology: Snorkel surveys involve a single upstream pass through each pool during daylight along a 1-km survey reach. The number of snorkelers employed will be based on what is needed to effectively cover the pool being snorkeled on a single upstream pass. To reduce problems associated with snorkeling in shallow or fast water habitat, only pools $\geq 6\ m^2$ in surface area and ≥ 40 cm deep are snorkeled. Counts of the number of juvenile and adult trout (*O. mykiss and Salvelinus confluentus*) and salmon (*O. tshawytscha*) are recorded for each pool. Trout and salmon will be categorized as juvenile (1+ years or greater), or adult based on size classes developed from local data and/or standards used by co-managers. Other species will be noted as present and recorded. Crewmembers either alternate the pools that they snorkel or one crewmember snorkels the entire reach. After snorkeling, the underwater visibility of each pool during the snorkel count is ranked on a scale of 0 to 3 where: 0 = not snorkelable due to an extreme amount of hiding cover or zero water visibility; 1 = high amount of hiding cover or poor water clarity; 2 = moderate amount of hiding cover or moderate water clarity neither of which were thought to impede accurate fish counts; and 3 = little hiding cover and good water clarity. Only pools with a visibility rank of two or three are used in data analysis. If all pools in a reach have visibilities < 2, then as many pools in the reach as possible will be electrofished using Smith-Root model 12-B backpack electrofishers following NMFS electrofishing guidelines for juvenile salmonid presence/absence. Electrofishing will be conducted by making a single pass upstream in each pool that meets the size and depth criteria for conducting snorkel surveys. No block nets will be used for this sampling. Electrofishing data will be combined with snorkeling data to determine the presence/absence of juvenile *O. mykiss* and spring Chinook. The presence/absence data will be analyzed to quantify the percent of sites where juvenile *O. mykiss* and spring Chinook are present as an estimate of juvenile distribution in the sample frame annually (e.g., 40% site occupancy).

To quantify the measurement error in the snorkel data, and to provide information on temporal changes in abundance during the course of the sampling season, supervisory staff will resurvey a random sample of 10 to 20 percent of the sites surveyed in each subbasin. Our goal is to limit between diver error to ± 20% or less with intensive presurvey training of field crews and regular random resurveys. Our approach in coastal watersheds has been to check crews early and often to ensure that the surveys are meeting the target precision levels. Once this is done, we have found no need to adjust the data. Since the crews know that any site may be re-surveyed at any time the focus on quality data has remained high. Five years of data and over 1000 sites surveyed have required no post-survey adjustment of the data. Re-surveyed sites that do not meet our precision goals are evaluated with the crew and re-done to meet the QC criteria.

Data analysis will involve calculating the percentage of survey sites that contain at least one juvenile fish for *O. mykiss* and spring Chinook and the percentage of pools per site that contain juvenile *O. mykiss* and spring Chinook to quantify changes in the relative distribution inter-annually. Analysis from coastal watersheds indicate that snorkeling data from pools has the strongest explanatory power regarding the overall trend is juvenile steelhead and coho populations. We will quantify the number of juvenile *O. mykiss* and spring Chinook observed per square meter for use in population trend analysis within and among individual subbasins. Confidence limits for summary estimates will be developed based on quantifying the measurement error in the snorkel data (see paragraph above) and site-to-site variability based on a variance estimator developed by the EPA EMAP Program for this application. Because juvenile salmonids have more diverse habitat requirements (rearing habitats are often different and dispersed relative to spawning habitat), evaluating their trends through time are necessary as an independent indicator of salmonids status.

7.b.2 – Juvenile emigrant abundance (see section 1.d.13).

<u>Monitoring and Evaluation Objective 7c</u>. Describe status and trends in adult abundance and productivity for all spring Chinook populations in the Imnaha and Grande Ronde subbasins.

Descriptive: Trend in adult abundance over time.

Descriptive: Monitor survival rates and abundance relative to management and conservation thresholds.

Key performance measures are adult abundance and derived measures of productivity (Lamda). We will use weir, mark- recapture, and redd count combinations depending on the population of interest (see section 1.a.1 and 1.a.2). These performance measures will be examined relative to annual and 8-year geometric means of minimum spawner escapement thresholds and ESA recovery criteria.

Given the comprehensive coverage of spawning ground surveys, EMAP protocols are not required for sample collection in every tributary. However, analysis could be accomplished through electronic subsampling of existing data to meet EMAP assumptions.

Methods

7.c.1 – Adult abundance to tributary by origin (see section 1.a.1).

7.c.2 – Index of spawner abundance (see section 1.a.2).

7.c.3- Population viability and risk analyses are discussed by Dennis et al. (1991). The authors suggest a 'Diffusion Approximation Model' sometimes called a Wiener-Drift process model. The model is used to analyze time series data from population size information. The DA model has two parameters: μ and σ^2. μ is the slope of the model, and σ^2 represents the variation of the error term. These two parameters determine various risk metrics to a population (Dennis et al. 1991) such as population growth rate of a long term, decline probability, time taken for a population size to reach a certain threshold, etc. The DA model was described previously (section 1.d).

Holmes (2003) suggests various variables to calculate a key parameter, "population growth rate of a long term" (λ). Those variables include logarithm of recruits per spawner, geometric means of natural cohort return rate for some year interval (say, 8 year interval), smolt-to-adult ratios, simple regression of log natural abundance against time, and residuals from a stock-recruit relationship, etc.

The estimate of λ determined from other parameters can be different from that calculated with μ and σ^2 and the DA model when using short-term data series. But the estimates from the two methods are equal when using long-term data sets (Caswell 2001). Yet, estimates of λ derived from the use of other variables do not cover the entire life cycle (Holmes 2003). In addition, the estimate of λ must be a measure of the integration of survivorship and fecundity over the entire life cycle rather than that of one stage's survivorship or fecundity alone.

Co-managers believe it is most efficient to use time series data from adult abundance rather than to use data from other variables. Results are robust when using the DA model with adult abundance data. However, if the data quality is not good enough to calculate accurate risk metrics, we will incorporate other data such as smolt abundance

Monitoring and Evaluation Objective 7d. Monitor spawning distribution in Grande Ronde and Imnaha subbasin Chinook populations.

Descriptive: Spatial distribution of adult spawners over time.

The key measure is redd distribution. We will use standard spawning ground survey methods and compare redd distribution between pre- and post-supplementation periods in the Lostine River, Catherine Creek, and Upper Grande Ronde River.

Salmon are renowned for their abilities to “home” back to the natal stream. Evidence indicates that homing salmonids frequently return to the same spawning area from which they emerged as fry. Olfactory cues stored during smolt emigration and later recalled in reverse order allow migrating adults to return to where they were spawned. Reaches where fish choose to spawn may be related to time of spawning, temperature, substrate size, etc. with later maturing fish tending to spawn further downstream. Co-managers will to determine how spawning adults are dispersing throughout the available spawning habitat. Redds and carcasses will be counted from foot surveys in spawning areas from late August to mid-September. Surveys will be conducted in known spawning areas covered by the traditional spawning ground survey transects (index and extensive area).

Methods

7.d.1 - Considerable adult survey work is currently underway to enumerate trends and distribution of adult spring Chinook via redd counts (see 1.a.2).

7.d.2 - The development of an EMAP- type probabilistic sampling scheme for redd counts will complement current survey efforts. Twenty-five random sites outside the traditional survey areas will be selected for each subbasin. Each site will be 1 km in length. Survey style will be based on protocols and methods used during traditional co-manager spawning ground surveys.

Monitoring and Evaluation Objective 7e. Contribute data to basin-wide effort to determine relationships between in-basin and out-of-basin habitat conditions and population productivity and abundance.

Co-managers will conduct correlation analysis for comparing survival and freshwater habitat conditions in the Imnaha and Grande Ronde subbasins.

MANAGEMENT OBJECTIVE 8: COORDINATE MONITORING AND EVALUATION ACTIVITIES AND COMMUNICATE PROGRAM FINDINGS TO RESOURCE MANAGERS.

Timely and thorough communication of the program’s status and performance is critical in the adaptive management process of hatchery programs. This is especially important given the co-management nature of this program, the dual authorization from the LSRCP and Northwest Power and Conservation Council (NPCC), and it’s relationship to the ESA. Facilitating the adaptive management framework involves elements of communication throughout the entire M&E program. Data management and summary reporting will be conducted by each entity performing specific M&E tasks. This information will be shared with co-managers through several ongoing regional communication and review processes such as website databases, summary reports, annual operation plans, co-management meetings, and performance review symposia. Every five years, materials will be summarized to facilitate a performance review of the hatchery program.

A monitoring and evaluation program, such as described in this plan, will result in the collection of extremely valuable data given society’s monetary investment and the important management questions to be answered. Hence, the volume and complexity of information gathered through the monitoring and evaluation activities will need to be compiled and organized in a systematic manner. It will involve archiving monitoring data, integrating data from different co-manager M&E activities, and making the data accessible in local and regional databases. For these reasons it is imperative that data management receive careful attention.

Monitoring and Evaluation Objective 8a. Provide accurate data summaries in a continual and timely manner.

With many of the data collection activities already being accomplished under multiple independent projects, NEOH M&E program will act as an organizer to link data sets. We will utilize project specific and region-wide databases that have been developed to centralize data associated with widely used data collection activities and standardized performance measures. A NEOH website will be maintained that will house a standardized database for primary data, description of meta-data, and summary/annual reports. Expanding either of the existing LSRCP or NEOH project websites will be considered to house the NEOH M&E information (http://lsnakecomplan.fws.gov and www.seattle-mwh.com/neoh/). Appropriate components of program data and results will be provided to the Pacific States Marine Fisheries Commission (PSMFC) websites, including: StreamNet, PIT Tag Information System (PTAGIS), and the Regional Mark Information System (RMIS). Fish production and release summaries including mark applications will be provided to the Fish Passage Center replacement for incorporation into their web based data.

Monitoring and Evaluation Objective 8b. Communicate study plans and results in a timely fashion locally and regionally.

Activities planned for in the annual Statement Of Work (SOW) for the NEOH M&E program will be reviewed by the co-managers for scientific validity, programmatic needs, and compliance with project objectives. Co-manger review will be facilitated through the LSRCP Evaluation Studies Guidelines (ESG) group. BPA will also review and approve annual SOWs for contractual compliance and obligations. Annual reports will be developed that provide data summary, data analysis, and data interpretation in relation to NEOH M&E program objectives and tasks. The reports will include a summaries and analyses of all data collected as part of the NEOH M&E program with recommendations for NEOH operations. Specific questions to be evaluated are:

- *Are the methods being used to collect data appropriate and the most effective to meet M&E objectives?*
- *Is the quality (level of statistical power) of data being collected sufficient for management recommendations?*
- *Has any of the uncertainty been removed and can any M&E activities be discontinued?*
- *Are the M&E findings sufficient to recommend program operation modification prior to the five-year review?*

Information provided in summary reports will be also be included in the annual report. Recommendations will be developed to address critical uncertainties and hypotheses. These reports will be posted electronically on the LSRCP/NEOH and BPA websites.

The 5-year report will include a summary of annual M&E results, annual recommendations and prescribed actions, analysis of multi-year (time series) data across all cohorts within a generation, an updated analysis of critical uncertainties, and recommendations about operation of NEOH and monitoring activities. The information will be presented in relation to M&E program goals, objectives, and management questions/hypotheses. This report will be posted electronically on the LSRCP/NEOH website.

Coordination of the NEOH M&E program activities is a continual process within the agencies and with co-managers in the Columbia River basin. Annual and semi-annual meetings with co-managers will be facilitated and attended to coordinated production and research activities.

Annual NEOH management review will use information from the NEOH M&E reports (summary, technical, and annual). Annual review will address:

- *Assessment of data and recommended changes to the risk levels assigned to all of the critical uncertainties.*
- *Assessment of NEOH performance in relation to set performance thresholds.*
- *Evaluation of NEOH performance in relation to NEOH goals and objectives.*
- *Review of recommendations made in the NEOH M&E annual reports.*

Monitoring and Evaluation Objective 8c. Support a scientifically sound adaptive management process of NEOH with M&E program findings.

We will implement a five-year review process for incorporating NEOH M&E information into the adaptive management process. Every five co-managers will facilitate a symposia to review NEOH performance and status. The five year review will be initiated with the development of a 5-year report that will serve as the framework for the symposia. The purpose of the performance review will be to:

- *Ensure adequate monitoring and evaluation is being conducted to evaluate both whether production is meeting its defined purpose and how well its operations improve survival and minimize adverse impacts.*
- *Evaluate the NEOH program for consistency with policies.*
- *Evaluate the NEOH program in terms of performance standards and identification of deficiencies.*

Monitoring and Evaluation Objective 8d. Coordinate needed and existing activities within agencies and between all co-managers.

An annual Statement of Work (SOW) will guide M&E activities for each project and will be based on the framework presented in the NEOH M&E Plan. The Annual Operating Plan of northeast Oregon co-managers will also provide direction. In addition to the NEOH program internally directed review, information from several regional processes will be considered in the adaptive management of NEOH. Information and recommendations from the Council, the Independent Hatchery Operations Team (IHOT), Artificial Production Review and Evaluations (APRE), ISRP, ISAB and NOAA Biological Opinion requirements will be utilized in the review process. The NEOH M&E program will also be coordinated with the regional monitoring and evaluation approach program currently being developed by PNAMP and CSMEP.

SUPPORTING ACTIVITIES AND PROGRAM COVERAGE

Key Performance Measures

Monitoring and evaluation of fisheries management occurs a multiple spatial scales for a wide variety of purposes. Regardless of the specific evaluation plan the attributes of a population being quantified are fairly consistent. Here we summarize the key performance measures in a fashion easily applicable to regional process.

The products needed from M&E programs are diverse. They range from operational requirements (i.e. mark hatchery fish), directly quantified performance measures (i.e. adult abundance), derived performance measures (i.e. progeny-parent ratios), and formal documents. Key performance measures (direct and derived) to be quantified are presented in Table 5. Duration and frequency of each sampling action/subaction are variable and are relative to their importance in describing program performance, biologically significant response/change period, and statistical replication. For example, performance measures related to adult abundance will be monitored annually, whereas quantification of available physical habitat will measured every 3 to 5 years.

Table 5. Summary of key performance measures in relation to spatial scale, frequency of sampling, and linkage to the Monitoring and Evaluation Objectives.

	Performance Measure	Spatial Scale	Frequency/ Duration	Monitoring and Evaluation Objectives
Abundance	Adult Escapement to Snake Basin	Subbasin-wide	Annual	
	Adult Escapement to Tributary	Primary Aggregates	Annual – ongoing	1a, 1b, 1d, 6b, 7c
	Adult Spawner Abundance	Primary Aggregates	Annual – ongoing	1a, 1d
	Index of Spawner Abundance (redd counts)	Subbasin-wide and Primary Aggregates	Annual – ongoing	1a, 1d, 7c
	Spawner Abundance	Primary Aggregates	Annual – ongoing	1a, 1d, 7c
	Hatchery Fraction	Primary Aggregates	Annual – ongoing	1a, 1b, 1d, 6b
	Harvest Abundance in Tributary	Key Areas	Annual	1a, 1d, 5b
	Index of Juvenile Abundance	Subbasin-wide	Annual	7b
	Juvenile Emigrate Abundance	Primary Aggregates	Annual	1d, 1e, 7b
	Hatchery Production Abundance	Key Areas	Annual	1a, 6a
	Smolt Equivalents	Primary Aggregates	Annual	1a, 1d, 1e
	Run Prediction	Key Areas	Annual, ongoing	5a, 6b
Su	Smolt-to-Adult Return Rate	Subbasin-wide and Key Areas	Annual	1e, 6a, 6b

	Performance Measure	Spatial Scale	Frequency/ Duration	Monitoring and Evaluation Objectives
	Progeny Parent Ratio (lambda, adult-to-adult)	Subbasin-wide and Key Areas	Annual for at least 10 years intervals	1a, 1d, 6c
	Recruit/spawner (smolt per female or redd)	Primary Aggregates	Annual	1a, 1d,
	Pre-spawn Mortality	Key Areas	Annual	1a, 1d
	Harvest Rate (ocean and Columbia River)	Primary Aggregates	Annual	
	Juvenile Survival to Lower Granite Dam	Primary Aggregates	Annual	1d, 1e, 6a
	Juvenile Survival to Mainstem (McNary and Bonneville) Dams	Subbasin-wide	Annual	7e
	In-hatchery Life Stage Survival	Key Areas	Annual	6a
	Post-release Survival	Key Areas	Annual	1e
	Relative Reproductive Success	Key Areas	Small-Scale Study (5 Years)	1b
Distribution	Adult Spawner Spatial Distribution	Subbasin-wide	3-5 year cycle	1c, 7d
	Stray Rate	Key Areas	Annual	4a, 4c
	Juvenile Rearing Distribution	Subbasin-wide	Annual (5 year cycle)	7b
	Disease Frequency	Primary Aggregates	Annual, Event Triggered	6c
Genetic	Genetic Diversity	Subbasin-wide and Key Areas	Small-scale Study (5 years)	2c, 3a
	Reproductive Success (Nb/N)	Primary Aggregates	Annual (5 year cycle)	2c, 3a
	Effective Population Size (Ne)	Primary Aggregates	Annual (5 year cycle)	2c, 3a
Life History	Age Class Sturcture	Primary Aggregates	Annual - ongoing	1a, 1b, 1d, 6b
	Age–at–Return	Primary Aggregates	Annual	1a, 1d, 2a, 3b, 6b
	Age–at-Emigration	Primary Aggregates	Annual	2b, 3c
	Size-at-Return	Primary Aggregates	Annual	2a, 3b
	Size-at-Emigration	Primary Aggregates	Annual	2b, 3c
	Condition of Juveniles at Emigration	Primary Aggregates	Annual – ongoing	2b, 3c
	Adult Spawner Sex Ratio	Primary Aggregates	Annual - ongoing	1a, 1b, 1d, 2a, 3b
	Fecundity by Age	Key Areas	Annual	1b, 3b
	Adult Run-timing	Key Areas	Annual	2a, 3b, 6a

	Performance Measure	Spatial Scale	Frequency/ Duration	Monitoring and Evaluation Objectives
	Spawn-timing	Key Areas	Annual	1b
	Juvenile Emigration Timing	Primary Aggregates	Annual	2b, 3c
	Mainstem Arrival Timing (Lower Granite)	Subbasin-wide	Annual	2b, 3c, 6a
Habitat	Physical Habitat	Subbasin-wide and Key Areas	Every three years	7a
	Stream Network	Subbasin-wide	10yrs	
	Passage Barriers/Diversions	Subbasin-wide	5 yrs	
	Instream Flow	Subbasin-wide and Key Areas	Continual (5 plus year cycle)	7a
	Water Temperature	Subbasin-wide and Key Areas	Continual (5 year cycles), Event Triggered	7a
	Chemical Water Quality	Subbasin-wide	Continual, 3 years	
	Macroinvertebrate Assemblage	Subbasin-wide	5 years	
	Fish and Amphibian Assemblage	Subbasin-wide	5 year	

MARKING APPROACH AND MANAGEMENT NEEDS

The identification of fish as members of a group or as individuals is one of the basic requirements for fisheries research and management. Fish tags and/or marks used for recognition purposes allow researchers to collect data from populations of interest that would not otherwise be available to them. The inability to differentiate between treatment groups and natural fish is a serious limitation of not marking or tagging at least a representative group of fish. Without marked or tagged fish, inferences about the mechanism associated with treatment responses would be precluded. The power of our experimental design would also be reduced because the opportunity to partition variability would then be limited. In addition, many production activities and operations of the NEOH facilities would not be possible without the ability to identify groups of fish.

Marking and tagging studies will provide NEOH co-managers with broad categories of information. Broodstock management, escapement estimates, juvenile and adult survival, migration and distribution, harvest quantification, and treatment group identification are all supported by marking and tagging fish. However, no single tag or mark can fulfill all our program needs. Each tag or mark has a different set of capabilities and limitations. Therefore, we will use several marks and tags to enhance our ability to evaluate supplementation and help meet management and M&E objectives. Current marking and tagging schemes will be reevaluated periodically as part of the overall NEOH program assessment. New marking or tagging techniques may also be considered to obtain a mark that has the least amount of impact to the fish but yields the necessary information.

Coded Wire Tags

The coded wire tag (CWT) was developed to obtain better management information than fin clipping alone could provide fisheries researchers. It was initially used to monitor returns of hatchery salmonids to various fisheries (Jefferts et al 1963). Coded wire tagging is an efficient means for mass making large numbers of fish with specific identifying codes. The tag has relatively minor biological effects on the tagged fish. The disadvantages are the absence of individual identification and the inability to recover codes from live fish (Bergman et al 1992). Since the tag is intended to remain within the fish for the entire life cycle animal, coded wire tags are suitable for population assessments, harvest appraisal and migration patterns.

All NEOH hatchery fish released as treatment groups will be marked with a coded wire tag. The CWT will make all treatment fish distinguishable from fish of other treatments, if a fish can be examined individually. Such opportunities will be available whenever hatchery adults are recovered as harvest, passing weirs, taken as broodstock, or recovered as carcasses.

Co-managers will use the information recovered from coded wire tags to evaluate conventional and captive broodstock progeny recruitment performance against each other and the standards set by their wild counterparts. Tag recoveries will provide tribal and recreational fisheries information to help quantify harvest and improve recruitment and escapement estimates. Artificial propagation may produce unexpected results. The coded wire tag allows co-managers to consider risk containment actions to address unacceptable level of straying from NEOH treatment groups (Hayes and Carmichael 2002). The level of straying into treatment streams from sources other than NEOH will also be monitored through the use of coded wire tags.

Adipose Fin Clip

Researchers have marked fish by fin clipping for many years because of its ease and relative low cost. Study results regarding the removal of fins and its effects on survival and growth have been variable. However, the clipping of the adipose fin does not appear to have any effect on survival or growth (Nielsen 1992). Therefore, co-managers will use an adipose fin clip as an external mark to identify NEOH hatchery fish and help distinguish hatchery and natural fish when they occur together. This mark will be used in combination with the internal coded wire tag for all treatment groups except conventional production groups from the upper Grande Ronde River (Appendix B).

Weir management, pass/keep protocols and broodstock collection decisions are possible when returning adult fish have a visible external mark. Current data collection procedures on spawning ground surveys and creel surveys are also dependant on the presence of an external mark.

Passive Integrated Transponder Tags

The passive integrated transponder (PIT) tag is a unique electronic identification system. After the initial tagging, the electronic chip within the tag allows the identification of individual fish with little or no handling. Data from these tags are valuable for migration and movement, growth and survival studies. The main advantage of this type of tag is the ability to identify individuals without sacrificing them (Nielsen 1992).

A representative group of PIT-tagged fish will be released with each NEOH treatment. A corresponding natural fish group from the same stream of origin will also be tagged and released. Detections of these PIT-tagged fish as they pass screw traps and dams provide information necessary to calculate treatment group and natural fish survivals. Sample size requirements for determining survival through the hydrosystem are estimated using the SURPH SAMPLE-SIZE program. Minimum release groups of 1,000 are needed to determine migration timing, median arrival dates and survival to Lower Granite Dam and 8,000 or more to McNary Dam and beyond. Valid SAR estimation will require the release of between 10,000 and 20,000 PIT tagged juveniles.

Co-managers currently tag and release approximately 2,500 upper Grande Ronde River hatchery fish, and 16,000 Lostine River hatchery fish each year. As part of the CSS study, 21,000 Catherine Creek and 21,000 Imnaha hatchery fish are tagged and released annually. Natural fish are tagged according to life stage. Five hundred natural parr, 500 presmolts and 500 smolts are targeted to receive a PIT tag from each treatment stream. Natural juveniles from reference streams with smolt traps are also receive PIT tags. The adequacy of our tagging numbers will be periodically reviewed by NEOH co-managers.

Visible Implant Elastomer

The visible implant elastomer (VIE) tag combines the advantages of internal and external tags. The tag is made of a biocompatible liquid that is injected into transparent tissue of a fish. The fluorescent color is visible through the membrane and thus can be used as an "external" batch-type mark. Olsen and Vollestad found no difference in growth or survival between VIE tagged and non-tagged fish (2001).

Both conventional and captive broodstock progeny are given an adipose fin clip to identify them as hatchery fish. However, only conventional progeny and natural origin fish may be used for hatchery broodstock. All retuning captive progeny must be passed above the weir to spawn naturally. Thus, for monitoring and broodstock management purposes, NEOH co-managers have decided to use the VIE tag to distinguish returning hatchery adults. All conventional juvenile fish released from NEOH facilities will be marked with VIE tags. When these hatchery groups return, a VIE mark in the adipose tissue behind the eye will allow discrimination at the weirs. Marking alternate sides of the fish each year will help separate brood years. In addition, Lostine, Upper Grande Ronde and Catherine Creek conventional juveniles will be marked with a different color according to parental stream.

Opercular Disc Tag and Opercular Hole Punch

All adult Chinook salmon interrogated at NEOH weirs are given either an opercular hole punch, opercular disc tag or a PIT tag in the operculum. Fish passed above the weir are given a pattern of opercular hole punches according to week and stream. This mark is used for mark and recapture population estimates after the marked fish are recovered as carcasses. The weekly punch pattern gives researchers information about distribution according to run timing.

Individual fish that are used for broodstock and brought to Lookingglass Fish Hatchery are identified by an external opercular disc tag with an alpha-numeric code or an internal PIT tag with an individualized code. Control of the hatchery:natural composition within hatchery broodstock management is a basic aspect of most production programs. The desired composition is based on program goals and status of the natural population segment. Both tags are currently being evaluated as a method to identify individual fish when sorting for maturity and ripeness and when developing spawning matrices.

Marking and Tagging Activities and Retention Monitoring

All hatchery-origin fish receive at least one mark or tag during juvenile rearing. Marking and tagging occurs at Lookingglass Fish Hatchery when juveniles are of appropriate size to receive the mark or tag. Juvenile hatchery fish are coded wire tagged in June, 10 months prior to their release. Their adipose fin is also clipped in June. Representative groups from the various treatments are PIT tagged in October, 6 months prior to release. Juveniles from the conventional program are given a VIE tag in November, 5 months before they are released.

Fish are sampled to estimate tag and mark retention prior to release**.** PIT tag retention is determined from tags recovered in the raceways at Lookingglass Fish Hatchery after tagging. The number of PIT tagged fish is also adjusted when tagged fish die and are recorded by hatchery personnel. The PIT tag release files are then updated before submitting them to PITAGIS.

Juveniles are sampled for coded wire tag and visible implant elastomer tag retention prior to the transfer of fish to the acclimation ponds. Five hundred fish per treatment pond are sampled in late February, 1-2 months prior to release to determine retention and correct for tag and mark loss. The mortality of fish with marks or tags are also recorded throughout the rearing process so that numbers reportedly released are as accurate as possible.

EXISTING AND PROPOSED PROJECTS

Co-managers work cooperatively in the effort to restore healthy ecosystems in the Imnaha and Grande Ronde subbasins. Thus, within the context of Chinook salmon recovery, a synergistic relationship exists between this proposed monitoring and evaluation program and numerous ongoing projects and endeavors in the subbasins. Ongoing research and M&E projects were developed to meet a diverse range of management needs. They have received extensive technical review by co-managers and the Independent Science Review Panel (ISRP) through the 2002 Blue Mountain and mainstem/system-wide Provincial Review processes. Existing projects include hatchery production evaluations under the LSRCP program and research and monitoring projects addressing natural population status. Regardless of the scope or status of the NEOH program, these research, monitoring, and evaluation projects are needed in the subbasins and are independent from NEOH program funding.

When viewed solely by the type of performance measures provided and spatial scale addressed, the ongoing projects provide a foundation for a M&E plan that supports evaluation of the NEOH program. Seventeen projects already provide certain aspects necessary for comprehensive monitoring and evaluation Table 6. In some cases, current efforts should be expanded to meet emerging information needs. Additionally, several important areas lack current investigation.

Managers recognize the necessary connection between supplementation as a recovery tool and habitat. Habitat condition is thought to be a limiting factor influencing salmon abundance in the Grande Ronde subbasin (Novak et al. 2001). Indeed, it is the current limitation of habitat that necessitates such a measure as the NEOH program. Many efforts are directed towards local habitat conditions in the Grande Ronde and Imnaha systems. These efforts relate directly to the NEOH program in that they influence the quality of the aquatic habitat inhabited by endangered salmon. Monitoring the habitat and effectiveness monitoring of habitat enhancement work are accomplished through the Grande Ronde Basin Fish Habitat Enhancement (BPA ID# 198402500), CTUIR Grande Ronde Subbasin Restoration (BPA ID# 199608300), and Grande Ronde Model Watershed Restoration projects (BPA ID# 199202601) projects. Monitoring efforts include water temperature, habitat transects, physical surveys, and photopoints. Some of these activities have occurred in the subbasins since 1984 and are integral components of a comprehensive monitoring and evaluation endeavor.

In-hatchery monitoring and evaluation of artificial production used for supplementation occurs through multiple on-going projects. The Captive Broodstock Artificial Propagation (BPA ID# 199801006), Grande Ronde Basin Spring Chinook Captive Broodstock Project (BPA ID# 199801001), and the Manchester Spring Chinook Broodstock Project (BPA ID# 199606700) provide the basis for evaluating the captive broodstock approach to salmon recovery. Specific expected research outcomes of the program include an evaluation of saltwater and freshwater adult rearing. Within the freshwater strategy, accelerated and normal growth regimes are also compared. These rearing treatments are evaluated in terms of size, survival, disease, fecundity, fertility, sperm motility, egg size, egg survival. The F1 juvenile and adult performance are then evaluated against the standards set by their wild counterparts.

In addition, the Lower Snake River Compensation Program (LSRCP) provides facilities, equipment, and personnel to assist production, evaluations, and fish health monitoring for

Northeast Oregon Chinook recovery projects. In-hatchery evaluations and comparartive adult performance after release are also conducted through the Lostine River O&M and M&E Project (BPA ID# 199800702) and Facility O&M and Program M&E (BPA ID# 199800703). These projects complement the NEOH M&E Action Plan by providing performance indicator information at several key life stages both in the hatchery and after release into the natural environment.

Supplementation is an experimental strategy that has considerable promise but also many associated uncertainties. The genetic consequences of supplementing natural populations with hatchery-reared fish are among those uncertainties. This issue cannot be addressed without an adequate monitoring program. The NMFS project entitled Monitor and Evaluate the Genetic Characteristics of Supplemented Salmon and Steelhead (BPA ID# 198909600) and a CRITFC genetics assessment contract provide NEOH co-managers with expertise and information regarding the nature and extent of the genetic impact of supplementation.

Performance standards are evaluated by multiple projects that monitor juvenile Chinook through various life stages from rearing areas through their emigration corridors. Imnaha River Smolt Survival and Smolt to Adult Return Rate Quantification (BPA ID# 199701501), Investigate Life History of Spring Chinook Salmon and Summer Steelhead in the Grande Ronde River Basin and Monitor Salmonid Populations and Habitat (BPA ID# 199202604), Smolt Monitoring by Federal and Non-Federal Agencies (BPA ID# 199701501) all furnish data to assess juvenile abundance, survival and life history traits.

Many of the specific M&E actions detailed in this plan are occurring through funded and on-going projects. They are capable of providing co-managers with the information necessary to answer many management questions and program uncertainties.

Table 6. Spring/summer Chinook salmon monitoring by Northeast Oregon co-managers. Numbers reference on-going BPA funded projects.

Subbasin		Grande Ronde River								Imnaha River			Out-of - Subbasin	
	Performance Measure	Lostine River	Upper Grande Ronde	Catherine Creek	Minam River	Wenaha River	Wallowa River	Hurricane Creek	Bear Creek	Imnaha River	Big Sheep Creek	Lick Creek	Secesh River	Marsh Creek
Abundance	Adult Escapement to Snake Basin													
	Adult Abundance to Tributary	8,12	4,12	4,12						12,13			3	
	Fish per Redd Estimate	8,12	4,12	4,12						12,13			3,10	11
	Index of Spawner Abundance (redd counts)	8,12	4,12	4,12	8,12,	8,12	8,12	8,12	8,12	12,13	12,13	12,13	3,10	11
	Hatchery Fraction	8,12	4,12	4,12	12	12	12	12	12	12	12	12	10	11
	Harvest	12,15	12,15	12,15	12,15	12,15	12,15	12,15	12,15	12,15	12,15	12,15	15	15
	Index of Juvenile Abundance (Density)	5	5	5	5	5						13	10	9,11
	Juvenile Emigrant Abundance	5	5	5	5					7			10	9,11
	Hatchery Production Abundance	1,2,8, 12	1,2,4, 12	1,2,4, 12						12,13				
	Smolt Equivalents	5	5	5	5					7			10	9,11
	Run Prediction	8,12	4,12	4,12						12			10	
Survival - Productivity	Smolt-to-Adult Return Rate	8,12	4,12, 18	4,12, 18	5,8, 12					7,12, 18			3,10	
	Parent Progeny Ratio (lambda, spawner -to-spawner)	8,12	4,12	4,12						12,13			3,10	
	Recruit/spawner (Smolt Equivalents per Redd)									7.12			3,10	
	Pre-spawn Mortality (female 0%)	8,12	4,12	4,12	8,12,	8,12	8,12	8,12	8,12	12,13			3,10	
	Juvenile Survival to Lower Granite Dam	8,5	5	5	5					7			10	9,11
	Juvenile Survival to all Mainstem Dams	8,5	5,18	5,18	5					7,18			10	9,11
	In-hatchery Life Stage Survival	1,2,8, 12,13	1,2,4, 12	1,2,4, 12						12,13				
	Post-release Survival	8,5	5	5						7				
Distribution	Adult Spawner Spatial Distribution	8,12	4,12	4,12	8,12	8,12	8,12	8,12	8,12	12,13			3,10	11
	Stray Rate	8,12, 17	4,12, 17	4,12, 17						12,13 ,17				
	Juvenile Rearing Distribution	5	5	5	5					5			10	11
	Disease Frequency													
Genetic	Genetic Diversity	6,8	6	6						6				
	Reproductive Success (Parentage)	19		19						19				
	Gene Conservation (Cryopreservation)	24	24	24						24			24	24
Life History	Age–at–Return	8,12	4,12	4,12	8,12	8,12	8,12	8,12	8,12	12,13			3,10	
	Age–at-Emigration	5	5	5	5					7			10	9,11
	Size-at-Return	8,12	4,12	4,12	8,12	8,12	8,12	8,12	8,12	12,13			3,10	
	Size-at-Emigration	5	5	5	5					7			10	9,11
	Condition of Juveniles at Emigration	8,5	5	5	5					7			10	9,11
	Adult Spawner Sex Ratio	8,12	4,12	4,12	8,12	8,12	8,12	8,12	8,12	12,13			3,10	
	Fecundity by Age	8,12	4,12	4,12						12,13				

Subbasin		Grande Ronde River								Imnaha River			Out-of - Subbasin	
Performance Measure		Lostine River	Upper Grande Ronde	Catherine Creek	Minam River	Wenaha River	Wallowa River	Hurricane Creek	Bear Creek	Imnaha River	Big Sheep Creek	Lick Creek	Secesh River	Marsh Creek
	Adult Run-timing	8	4	4	22					12,13			3	
	Spawn-timing	8,12	4,12	4,12	8,12	8,12	8,12	8,12	8,12	12,13			3,10	
	Juvenile Emigration Timing	5	5	5	5					7			10	9,11
	Mainstem Arrival Timing (Lower Granite)	8,5	5,18	5,18	5					7,18			10	9,11
Habitat	Physical Habitat		19,20,21	19,20,21			22	22						
Habitat	Stream Network													
Habitat	Passage Barriers/Diversions	22					22	22	22	22	22	22		
Habitat	Instream Flow	8			5					7				
Habitat	Water Temperature	8	4	4						7				
Habitat	Chemical Water Quality													
Habitat	Macroinvertebrate Assemblage													
Habitat	Fish and Amphibian Assemblage	5	5	5	5	5	5	5	5					

Projects Providing Primary Data

1. Captive Broodstock Artificial Propagation (BPA # 199801006): 1998 - present
2. Grande Ronde Basin Spring Chinook Captive Broodstock Project (BPA # 199801001): 1995 - present
3. Chinook Salmon Adult Abundance Monitoring (BPA# 199703000): 1997-present
4. Facility O&M and program M&E for Grande Ronde Spring Chinook Salmon (BPA # 199800703): 1997 - present
5. Life History of Spring Chinook Salmon and Steelhead (BPA # 199202604): 1993 - present
6. Monitor and Evaluate Genetic Characteristics of Supplemented Salmon and Steelhead (BPA # 198909600): 1989 - present (new DNA Parentage started in 2004)
7. Imnaha River Smolt Monitoring Program (BPA # 199701501): 1994 - present
8. Lostine River Supplementation O&M/M&E (BPA # 199800702): 1997 - present
9. NOAA PIT Tagging Wild Chinook (BPA # 199102800): 1992 - present
10. NPT Idaho Supplementation Studies (BPA # 198909802): 1989 - present
11. IDFG Idaho Supplementation Studies (BPA # 198909800): 1987 - present
12. ODFW Lower Snake River Compensation Plan Evaluations (BPA # 200109): 1983 - present
13. NPT Lower Snake River Compensation Plan Evaluations (BPA # 200107): 1985 - present
14. Smolt Monitoring by Federal & Non- Federal Entities (BPA # 198712700): 1982 - present
15. NPT Harvest Monitoring Program (BPA # 200206000): 2002 - present
16. PSMFC Columbia Basin PIT tag Information System (BPA # 199008000): 1981 - present
17. PSMFC Coded Wire Tag Recovery (BPA # 198201301): 1982 - present
18. USFWS-CRFPO Comparative Survival Studies (BPA # 199602000): 1996 - present

Projects Providing Supportive Data

19. Grande Ronde Model Watershed Habitat Projects (BPA # 199202601): 1992 - present
20. Grande Ronde Subbasin Restoration (BPA # 199608300): 1996 - present
21. Grande Ronde Basin Fish Habitat Enhancement (BPA # 198402500): 1984 - present
22. Wallowa County Culvert Inventory (BPA # 200207300): 2003 - present
23. Manchester Spring Chinook Broodstock Project (BPA # 199606700): 1996 - present
24. Listed Stock Chinook Salmon Gamete Preservation (BPA # 199703800): 1997 - present

PRIORITIZATION

Introduction

As part of the Northeast Oregon Hatchery (NEOH) Step 3 planning process, co-managers were asked by Bonneville Power Administration and the Northwest Power and Conservation Council (NPCC) to present an approach for prioritizing components within the NEOH Monitoring and Evaluation Plan (NWPCC 2004). The Independent Scientific Review Panel (ISRP) also recommended to co-managers a ranking of management questions and objectives by priority (ISRP 2004-10).

The NEOH co-managers are well aware of the need to prioritize in an era of limited environmental funding (Bahcall 1991; Fisher et al. 2004). It may be unlikely that co-managers will acquire the financial resources necessary to implement all the of monitoring and evaluation activities identified in NEOH Monitoring and Evaluation Plan (Hesse et al. 2004). Yet, even in light of these financial constraints, we continue to believe that all the NEOH goals and objectives are important. We agree with the ISRP that the NEOH M&E Plan "*has the potential, if implemented, to address critical uncertainties pertaining to wild and hatchery interactions. It may also serve as a model for other supplementation programs in refining their monitoring and evaluation plans*" (ISRP 2005-14). Therefore, we developed a prioritization scheme that allocates resources across our objectives and performance measures in what we believe is a prudent and efficient manner. The following describes our approach to setting priorities within the NEOH M&E plan and the associated project costs per funding alternatives.

As we face these challenging economic circumstances, it is important to keep in mind that monitoring and evaluation have long been recognized as necessary components of natural resource management. In appreciation of their necessity, the Council has frequently voiced support for vigorous monitoring and evaluation programs (NWPCC 2000). The Council writes of its current Fish and Wildlife Program:

> *"The Program's success cannot be measured and demonstrated without an adequate monitoring and evaluation framework. It is anticipated that a more regimented program framework will facilitate the design of a more robust and effective monitoring and evaluation program. The Council firmly believes that this should be a major objective for the next program."*

The Council and the ISRP also concur with each other regarding the essential prerequisite of monitoring and evaluation when judging the success of supplementation programs (ISRP 2005-14). It is the monitoring and evaluation effort that will address uncertainty specific to hatchery intervention in the Grande Ronde and Imnaha subbasins, indicate recovery benefits to the target populations, and add to our knowledge regarding supplementation in general. It is also the NEOH monitoring and evaluation effort that will serve the regional processes of the Collaborative Systemwide Monitoring and Evaluation Project (CSMEP), the NOAA Fisheries' Research, Monitoring & Evaluation Plan, and the Pacific Northwest Aquatic Monitoring Partnership (PNAMP).

Society has invested large sums of money in the Grande Ronde and Imnaha subbasins for the sake of the salmon. Without effective and comprehensive monitoring and evaluation in place, the actual response of salmon populations to conservation strategies will remain largely unknown. Monitoring and evaluation provide the accountability that is necessary for a viable, long-term salmon conservation effort in northeast Oregon. Therefore, "the cost of *not* monitoring is simply too high" (Botkin et al 2000).

Approach

Co-managers quickly reached consensus that existing research and monitoring projects should retain their current priority. Many of the specific M&E actions detailed in the M&E plan are occurring now through funded and on-going projects. These projects were developed to meet many of the same management needs as described in the NEOH M&E plan. They have received extensive technical review by co-managers and the Independent Science Review Panel through the 2002 Blue Mountain and mainstem/system-wide Provincial Review processes. They are capable of providing co-managers with much of the information necessary to answer management questions and program uncertainties in northeast Oregon.

When viewed solely by the type of performance measures provided and M&E objectives addressed, the ongoing projects represent approximately 75% of the proposed NEOH M&E Plan (Hesse et al. 2004). However, 25% of the identified performance measures remain unaddressed or are currently inadequately addressed. New projects and their estimated costs were proposed to cover habitat areas, reference streams, performance measures and data needs not covered by existing M&E projects in northeast Oregon (Appendix A). It was the collective cost total for these new projects that co-managers submitted to the Council as part of the Step 2 process. Our prioritization effort is directed toward these new projects and funds after prioritizing objectives and performance measures.

Ranking Rational

The Independent Scientific Advisory Board (ISAB) outlined a monitoring and evaluation plan for assessing supplementation (Bilby et al. 2003). They described a three-tiered approach to monitoring involving trend analysis, statistical inferences from appropriate performance measures and experimental research. In addition, the ISRP recommended viewing supplementation projects as a large scale manipulative experiment and testing the major hypotheses associated with supplementation as a rebuilding and recovery tool. Variables to be tested in a solid stock appraisal and supplementation assessment should include adult escapement, smolt yield, smolts-per spawner, harvest, and trends in these statistics over time periods that define the productivity and capacity of the system (ISRP 2002). The National Marine Fisheries Service (NOAA) also recommended characterizing populations by abundance/productivity, diversity (viability), spatial structure, and habitat capacity.

Based on these recommendations, co-managers designed the NEOH M&E Plan to address management objectives and answer questions fundamental to Chinook salmon recovery in northeast Oregon. In addition, many of the goals, objectives, needs, and strategies detailed in the Grande Ronde Subbasin Plan are addressed by the NEOH M&E Plan. In particular, the aquatic monitoring and evaluation objectives and their associated performance measures in the subbasin plan are consistent with the objectives found in the NEOH M&E Plan. Specific RM&E needs outlined in the subbasin plan and directly related to monitoring and evaluation are as follows:

- “Describe status and trends in adult abundance and productivity for all focal populations…” (pg 276).
- “Monitor focal species spawning distributions …” (pg 277).
- “Determine and compare relative reproductive success of hatchery and naturally produced focal species” (pg 279).
- “Determine and compare adult life history characteristics between hatchery and natural fish…” (pg 282).
- “Data information archive” (pg 288).
- “Coordination and implementation” (pg 289).

Therefore, our decisions in prioritizing were based on the recommendations of the ISAB, ISRP, NOAA and the Grande Ronde Subbasin Plan. We also included what we, as co-managers, believed was of greatest importance in terms of management need. Our areas of primary interest are:

- Population status as a function of numbers, distribution, age, and genetic diversity. This is austere monitoring, but an essential component of fisheries management, ESA listing and delisting criteria, and BIOP mandates.
- Comparative performance of hatchery fish relative to their natural counterparts regarding parent:progeny ratios, relative reproductive success, genetic diversity, and contribution to harvest and natural escapement.
- Life history traits of the natural and hatchery segments of the population.
- Habitat condition and use. Stock status and performance can be evaluated only with respect to the properties of the natural environment in which the population is found.
- Reference stream comparisons. The references offer the standard by which results are compared. Thus, to explicitly test supplementation as a recovery tool, it is necessary to compare the treatment (supplemented) stream against a comparable but untreated stream (Bilby et al. 2003).
- Disseminating learned information.

Priority Objectives - Prioritization can be expressed at multiple scales within the management processes. We can set priorities for our objectives down to the performance measures that we quantify, i.e. what data is actually collected. Focused on the key areas of interest above, we initially prioritized according to M&E objectives as requested by the Council. These M&E objectives were derived from the NEOH monitoring and evaluation goal (Hesse et al. 2004). The M&E objectives illustrate the essential characteristics and conditions of the NEOH populations of interest and describe management outcomes as reflected in those populations. Our first step in prioritizing was to assign a qualitative ranking of the research benefit to each objective. Our ranking categories in descending order are “Essential” (E), “Recommended” (R) and “Lower Priority” (LP) as presented in *Table 7*.

Table 7. NEOH Monitoring & Evaluation Objectives Ranked by Priority ("Essential", "Recommended" and "Lower Priority").

Ranking	Objective	Description
Essential	Monitoring and Evaluation Objective 1a	Determine and compare productivity of hatchery and naturally produced fish in Imnaha, Lostine, and Upper Grande Ronde rivers and Catherine and Lookingglass creeks.
Essential	Monitoring and Evaluation Objective 1b	Determine and compare relative reproductive success of hatchery and naturally produced Chinook salmon.
Essential	Monitoring and Evaluation Objective 1c	Determine and compare the spawning distribution of hatchery and natural origin Chinook in Imnaha, Lostine, upper Grande Ronde rivers and Catherine Creek.
Essential	Monitoring and Evaluation Objective 1d	Determine the effects of hatchery supplementation on the abundance and productivity of Imnaha, Lostine, upper Grande Ronde rivers and Catherine Creek spring Chinook salmon populations.
Essential	Monitoring and Evaluation Objective 1e	Determine and compare life-stage specific survival rates for hatchery and natural fish in the Imnaha, Lostine, Upper Grande Ronde rivers and Catherine Creek.
Essential	Monitoring and Evaluation Objective 2a	Determine adult life history characteristics of naturally produced fish in supplemented and unsupplemented populations in the Lostine, Minam, Wenaha, and upper Grande Ronde rivers and Catherine Creek and compare to pre-supplementation characteristics.
Essential	Monitoring and Evaluation Objective 2b	Determine juvenile life history characteristics of naturally produced fish in supplemented populations in the Lostine, and upper Grande Ronde rivers and Catherine Creek and compare to pre-supplementation characteristics.
Essential	Monitoring and Evaluation Objective 3b.	Determine and compare adult life history characteristics between hatchery and natural fish in Catherine Creek, Lostine, upper Grande Ronde and Imnaha rivers.
Essential	Monitoring and Evaluation Objective 4a	Determine the proportion of naturally spawning fish that are stray hatchery fish (stray composition) in the Minam and Wenaha rivers
Essential	Monitoring and Evaluation Objective 5a	Develop precise and accurate pre-season hatchery and natural fish escapement predictors.
Essential	Monitoring and Evaluation Objective 5b	Determine annual tribal and recreational catch, harvest, and effort for hatchery and naturally produced spring Chinook salmon.
Essential	Monitoring and Evaluation Objective 7c	Describe status and trends in adult abundance and productivity for all spring Chinook populations in the Imnaha and Grande Ronde subbasins.
Essential	Monitoring and Evaluation Objective 7e	Monitor survival rates and abundance relative to management and conservation thresholds.
Essential	Monitoring and Evaluation Objective 8a	Provide accurate data summaries in a continual and timely manner
Essential	Monitoring and Evaluation Objective 8c	Support a scientifically sound adaptive management process of NEOH with M&E program findings.
Essential	Monitoring and Evaluation Objective 8d	Coordinate needed and existing activities within agencies and between all co-managers.
Recommended	Monitoring and Evaluation Objective 2c	Monitor genetic characteristics in supplemented and unsupplemented populations to assess degree and rate of change.
Recommended	Monitoring and Evaluation Objective 3a	Determine and compare genetic characteristics of hatchery and natural fish in Catherine Creek, Lostine, upper Grande Ronde and Imnaha populations.
Recommended	Monitoring and Evaluation Objective 3c	Determine and compare smolt migration characteristics between natural and hatchery smolts in the Imnaha, Lostine, upper Grande Ronde rivers and Catherine Creek
Recommended	Monitoring and Evaluation	Determine origin of stray hatchery fish in the Minam and Wenaha rivers.

	Objective 4b	
Recommended	Monitoring and Evaluation Objective 4c	Determine distribution and stray rates of Catherine Creek, Lostine, upper Grande Ronde and Imnaha river hatchery fish.
Recommended	Monitoring and Evaluation Objective 6a.	Determine the influence of production strategy on smolt emigration characteristics, smolt-to-adult survival, and age structure for each experimental unit within production groups.
Recommended	Monitoring and Evaluation Objective 7a	Determine status and trends of Chinook salmon habitat in the Imnaha and Grande Ronde subbasins.
Recommended	Monitoring and Evaluation Objective 7b	Describe status and trends in juvenile abundance at the population and subbasin scales in the Imnaha and Grande Ronde subbasins.
Recommended	Monitoring and Evaluation Objective 7d	Monitor spawning distribution in Grande Ronde and Imnaha subbasin Chinook populations.
Recommended	Monitoring and Evaluation Objective 8b	Communicate study plans and results in a timely fashion to local and regional entities.
Lower Priority	Monitoring and Evaluation Objective 6b	Compare management plan objectives and actions with program outcomes to determine plan feasibility and effectiveness.
Lower Priority	Monitoring and Evaluation Objective 6c	Determine disease presence and prevalence in supplemented populations and compare with pre-supplemented presence and prevalence.

Priority Performance Measures - We then prioritized the performance measures found in the M&E plan. A suitable experimental design requires identification of various indicators that are sensitive to natural events or human manipulation and are useful in judging performance according to specific M&E objectives (Cairns et al. 1993). Hesse et al. (2004) link NEOH performance measures to NEOH M&E objectives in tables ES1 and 5 of the plan. In its *Review of Salmon and Steelhead Supplementation*, the ISAB recommended that performance measures be established for natural origin and hatchery origin adult abundance, their respective reproductive rates and the comparative monitoring of reference populations (Bilby et al. 2003). Therefore, our criteria for ranking performances measures are linked to our objectives and related to the ISAB report. Other considerations for ranking performance measures are:

1) Performance measures that provide information specific to co-mangers' primary areas of interest.
2) Performance measures that serve multiple objectives.
3) Performance measures that can provide applicable information to the subbasin and to the region.
4) Performance measures capable of providing information for multiple focal species.
5) Cost, infrastructure and logistics required to collect performance measure data.

We used the same categories for ranking as with the M&E objectives ("Essential" - E, "Recommended" - R and "Lower Priority" – LP). *Table 8* depicts co-managers prioritization according to performance measure and areas of interest.

Table 8. Performance Measures Ranked as "Essential"- E , "Recommended"- R,- and "Lower Priority" – LP.

Ranking	Performance Measure	
R	Adult Escapement to Snake Basin	Abundance
E	Adult Abundance to Tributary	
E	Fish per Redd Estimate	
E	Index of Spawner Abundance (redd counts)	
E	Hatchery Fraction	
E	Harvest	
LP	Index of Juvenile Abundance (Density)	
E	Juvenile Emigrant Abundance	
E	Hatchery Production Abundance	
E	Smolt Equivalents	
E	Run Prediction	
E	Smolt-to-Adult Return Rate	Survival -Productivity
E	Parent Progeny Ratio (lambda, spawner -to-spawner)	
R	Recruit/spawner (Smolt Equivalents per Redd)	
E	Pre-spawn Mortality (female 0%)	
R	Juvenile Survival to Lower Granite Dam	
LP	Juvenile Survival to all Mainstem Dams	
R	In-hatchery Life Stage Survival	
LP	Post-Release Survival	
E	Relative Reproductive Success (Parentage)	
R	Adult Spawner Spatial Distribution	Distribution
R	Stray Rate	
LP	Juvenile Rearing Distribution	
R	Disease Frequency	

Ranking	Performance Measure	
R	Genetic Diversity	Genetics
E	Reproductive Success (Nb/N)	
R	Effective Population Size (Ne)	
R	Age Class Structure	Life History Characteristics
E	Age–at–Return	
LP	Age–at-Emigration	
R	Size-at-Return	
R	Size-at-Emigration	
LP	Condition of Juveniles at Emigration	
E	Adult Spawner Sex Ratio	
LP	Fecundity by Age	
E	Adult Run-timing	
R	Spawn-timing	
E	Juvenile Emigration Timing	
R	Mainstem Arrival Timing (Lower Granite)	
R	Physical Habitat	Habitat & Environment
LP	Stream Network	
R	Passage Barriers/Diversions	
E	Instream Flow	
E	Water Temperature	
LP	Chemical Water Quality	
LP	Macroinvertebrate Assemblage	
LP	Fish and Amphibian Assemblage	

LITERATURE CITED

Achord, S., J.R. Harmaon, D.M. Marsh, B.P. Sandford, K.W. McIntyre, K. L. Thomas, N.N. Paasch, and G.W. Matthews. 1992. Research related to transportation of juvenile salmonids on the Columbia and Snake rivers, 1991. National Marine Fisheries Science, Seattle, Washington.

Ashe, B.L., A. C. Miller, P. A. Kucera, M. L. Blenden. 1995. Spring outmigration of wild and hatchery Chinook salmon and steelhead trout smolts from the Imnaha River, March 1 - June 15, 1994. Bonneville Power Administration, Portland, OR., DOE/BP-38906-4.

Ashe, B., Concannon, K., Johnson, D. B., Zollman, R. L., Bryson, D. and Alley, G. (2000). Northeast Oregon Hatchery Project (NEOH) Spring Chinook Master Plan. Nez Perce Tribe, Lapwai, Idaho

Beamesderfer, R. C., H. A. Schaller, M. P. Zimmerman, C. E. Petrosky, O. P. Langness, and L. LaVoy. 1997. Spawner-recruit data for spring and summer Chinook salmon populations in Idaho, Oregon, and Washington in D. R. Marmorek and C. Peters (eds.) Plan for analyzing and testing hypotheses (PATH): report of retrospective analysis for fiscal year 1997. ESSA Technologies Ltd, Vancouver, B.C., Canada.

Beerli, P. and J. Felsenstein. 1999. Maximum-likelihood estimation of migration rates and effective population numbers in two populations using a coalescent approach. Genetics 152:763-73.

Bergman, P.K., F. Haw, H. L. Blankenship, and R.M. Buckley. 1992. Perspectives on design, use, and misuse of fish tags. Fisheries 17 (4):20-25.

Bilby, R.E., P.A. Bisson, C.C. Coutant, D. Goodman, R.B. Gramling, S. Hanna, E.J. Loudenslager, L.McDonald, D.P. Philipp, R.Riddell, R.N. Williams. 2003. Independent Scientific Advisory Board review of salmon and steelhead supplementation. Prepared for the Northwest Power Planning Council and the National Marine Fisheries Service. ISAB 2003-03, Portland, Oregon.

Bisbal, G.A. 2001. Conceptual design of monitoring and evaluation plans for fish and wildlife in the Columbia River ecosystem. Environmental Management, 28(4):433-453.

Bjornn, T.C., R.R. Ringe, K.R. Tolotti, P.J. Keniry, J.P. Hunt C.J. Knutsen, and S.M. Knapp. 1992. Migration of adult Chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries – 1991. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Bjornn, T.C., J.P. Hunt, K.R. Tolotti, P.J. Keniry, and R.R. Ringe. 1993. Migration of adult Chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries – 1992. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho for U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Blenden, M.L. R.S. Osborne, and P.A. Kucera. 1996. Annual report: spring outmigration of wild and hatchery Chinook salmon and steelhead smolts from the Imnaha River, Oregon, February 6, to June 16, 1995. Bonneville Power Administration, Fish and Wildlife Dicvsion, Portland, Oregon.

Botkin, D.B., D.L. Peterson, and J.M. Calhoun (technical editors). 2000. The scientific basis for validation monitoring of salmon for conservation and restoration plans. Olympic Natural Resources Technical Report. University of Washington, Olympic Natural Resources Center, Forks, Washington, USA.

Bryson, D., C. Rabe, A. Davidson, and D. Saul. 2001. Draft Imnaha Subbasin Summary. Prepared for the Northwest Power Planning Council, pp. 219.

Cairns, J.C., Jr., P.V. McCormick and B.R. Niederlehner. 1993 A proposed framework for developing indicators of ecosystem health. Hydrobiologia 263: 1-44.

Caswell, H. 2001. Matrix population models. Sinauer, Sunderland, Mass.

Carmichael, R.W., and R.T. Boyce. 1986. U.S. v. Oregon. Imnaha spring Chinook production report. Oregon Department of Fish and Wildlife.

Carmichael, R.W., and R.T. Boyce. 1986. U.S. v. Oregon. Grande Ronde spring Chinook production report. Oregon Department of Fish and Wildlife.

Carmichael, R.W., and R.T. Messmer. 1995. Status of supplementing Chinook salmon natural production in the Imnaha River Basin. Pages 284-291 *in* H.L. Schramm, Jr., and R.G. Piper, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society, Bethesda, Maryland.

Carmichael, R.W., S.J. Parker, and T.A. Whitsel. 1998. Status review of the Chinook salmon hatchery program in the Imnaha River basin, Oregon. In Lower Snake River Compensation Plan Status Review Symposium, February 1998. USFWS LSRCP, Boise, Idaho.

Chapman, D. G. 1951. Some properties of the hypergeometric distribution with applications to Zoological censuses. University of California Publications in Statistics 1:131-160

Chapman, D.G., and C.O. Junge. 1956. The estimation of the size of a stratified animal population. Annuals of Mathematical Statistics 27: 375- 389.

Chilcote, M.W., Leider, S.A., and J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Trans. Am. Fish. Soc. 115:726-735.

Cleary, P.J., M.L. Blenden, and P.A. Kucera . 1998. Annual report: emigration of natural and hatchery Chinook salmon and steelhead smolts from the Imnaha River, Oregon, October 14, 1997 to June 16, 1998. Nez Perce Tribe Department of Fisheries Resources Management. Lapwai, Idaho

Cleary, P.J., M.L. Blenden, K. Gillogly, and P.A. Kucera . 2000. Annual report: Emigration of natural and hatchery Chinook salmon and steelhead smolts from the Imnaha River, Oregon, October 20, 1999 to June 15, 2000. Nez Perce Tribe Department of Fisheries Resources Management. Lapwai, Idaho.

Cleary, P.J., P. A. Kucera, M.L. Blenden, N. Espinosa, and C.M. Albee. 2003. Annual report: Emigration of natural and hatchery Chinook salmon and steelhead smolts from the Imnaha River, Oregon, October 17 , 2000 to June 12, 2002. Nez Perce Tribe Department of Fisheries Resources Management. Lapwai, Idaho.

Cohen, J. 1988.statistical power analysis fpr the behavior sciences. Lawrence-Erlbaum, Hilldsale, NJ.

Cousins, N.B.F, G.A. Thomas, C.G. Swan, and M.C. Healey. 1982. A review of salmon Escapement estimation techniques. Canadian Technical Report of Fisheries and Aquatic Science 1108.

Crow, J.F. and C. Denniston. 1988. Inbreeding and variance effective population numbers. Evolution 42: 482-485.

Currens, K., J. Lannan, B. Riddel, D. Tave, and C. Wood. 1996. Responses of the Independent Scientific Panel to questions about the interpretation of genetic data for spring Chinook in the Grande Ronde basin. US v Oregon Dispute Resolution Document.

Darroch, J.N. 1961. Two –Sample capture- recapture census when tagging and samplings are stratified. Biometrics 23 (4): 639-645.

De Libero, F.E. 1986. A statistical assessment of the use of the coded wire tag for Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) studies. Ph.D. dissertation, Univ. of Washington, Seattle, Wash. 228 pp.

Dennis, B., P.L. Munholland, and J.M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs, 61(2): 115-143.

Downing, S.L., E.F. Prentice, B.W. Peterson, E.P. Nunnallee, and B.F. Jonasson. 2000. A Study To Determine The Biological Feasibility Of A New Fish-Tagging System, 1998-99. Bonneville Power Administration. Contract 97-AI-31168. Portland, OR

Everhart, W.H. and W.D. Young. 1992. Principles of Fishery Science. Cornell University Press, Ithaca, New York.

Ford, M. J. 1998. Testing models of migration and isolation among populations of Chinook salmon (*Oncorhynchus tshawytscha*). Evolution 52:539-557.

Ford, M. J. 2000. Effects of natural selection on patterns of DNA sequence variation at the transferrin, somatolactin, and p53 genes within and among Chinook salmon *(Oncorhynchus tshawytscha*) populations. Molec. Ecol. 9:843-855.

Ford, M. J. 2002a. Selection in captivity during supportive breeding may reduce fitness in the wild. Conservation Biology 16:815-825.

Ford, M. J. 2002b. Applications of selective neutrality tests to molecular ecology, a review. Molecular Ecology, *in press*

Garant, D., Dodson, J.J. & Bernatchez, L. 2001. A genetic mating system and determinants of individual reproductive success in Atlantic salmon (*Salmo salar* L.). Journal of Heredity 92:137-145.

Gharrett, A.J., and W.W. Smoker. 1993. Genetic components in life history traits contribute to population structure. Pages 197-202 *in* J.G. Cloud and G.H. Thorgaard (ed). Genetic conservation of salmonid fishes. Plenum Press, New York.

Giorgi, A.E. and L. Stuehrenberg.. 1988. Lower granite pool and turbine survival study, 1987. Portland, Bonneville Power Administration. Oregon:30.

Glass, B., and C. C. Li. 1953. The dynamics of racial intermixture--an analysis based on the American Negro. Am. J. Hum. Genet. 7:368-385.

Goel, N.S., and N. Richter-Dyn. 1974. Stochastic models in biology. Academic Press, New York, New York, USA.

Goudet, J., M. Raymond, T. De Meeüs, and F. Rousset. 1996. Testing differentiation in diploid populations. Genetics 144:1933-1940

Gunderson, D.R. 1993. Surveys of fisheries resources. John Wiley & Sons, Inc. New York. 248 pp.

Harbeck, J.R. 2003. Personal Communication.

Hayes, M.C. and R.W. Carmichael. 2002. Salmon restoration in the Umatilla River: a study of straying and risk containment. Fisheries 27 (10):10-19.

Hesse, J.A. and S.P. Cramer. 2000. Monitoring and evaluation plan for the Nez Perce Tribal Hatchery: Phase 1 Action Plan. Prepared for Bonneville Power Administration, Project no. 8335000.

Hesse, J.A., and J.R. Harbeck. 2000. Northeast Oregon hatchery spring/summer Chinook salmon conceptual monitoring and evaluation plan. Prepared for Bonneville Power Administration. DOE/BP-3267.

Hill, W. G. 1981. Estimation of effective population size from data on linkage disequilibrium. Genet. Res. (Cambridge) 38: 209-216.

Hillman, T.W., 2003. Draft monitoring strategy for the upper Columbia Basin. Prepared for the Upper Columbia Regional Technical Team and the Upper Columbia Salmon recovery Board. BioAnalysts, Eagle, Idaho.

Holmes, E.E. 2001. Estimating risks in declining populations with poor data. Proceedings of the National Academy of Science USA 98: 5072-5077.

Holmes, E.E., and W.F. Fagan. 2002. Validating population viability analysis for corrupted data sets. Ecology 83 (9): 2379-2386.\

Holmes, E.E. 2003. Review of methods, progress and cross-validation studies pertaining to population trend and risk assessment for Columbia River salmonids. White paper for the FCRPS Biological Opinion.

Hurato, J.. 1993. Grande Ronde Subbasin Plans, Spring Chinook. Oregon Department of Fish and Wildlife. LaGrande, Oregon.

Hyun, S., and Talbot, A. 2004. Status of Snake River spring/summer Chinook salmon and steelhead by an integrated risk metric. Columbia River Inter-Tribal Fish Commision report for Bonneville Power Administration. 41 pp.

Independent Scientific Group. 1996. Return to the river: Restoration of salmonid fishes in the Columbia river ecosystem. Northwest Power Planning Council, Portland, Oregon.

Independent Scientific Review Panel (ISRP). 1997. Review of the Columbia River Basin Fish and Wildlife Program as directed by the 1996 amendment to the Power Act. ISRP Report 97-1.

Independent Science Review Panel (ISRP). 2000. Final review of fiscal year 2001 project proposals for the Columbia River Gorge and Inter-Mountain Province. Prepared for the Northwest Power Planning Council. ISRP 2000-9.

Independent Science Review Panel (ISRP). 2001. Review of NMFS proposal “evaluate hatchery performance principles.” Prepared for the Northwest Power Planning Council. ISRP 2001-5.

Independent Science Review Panel (ISRP). 2002. Review of council staff’s research plan for fish and wildlife in the Columbia River Basin. Prepared for the Northwest Power Planning Council. ISRP 2002-4.

Independent Science Review Panel (ISRP). 2003. Review of revised mainstem systemwide proposals for research, monitoring and evaluation. Prepared for the Northwest Power Planning Council. ISRP 2003-6.

ICTRT (Interior Columbia Technical Recovery Team). 2005. Interior Columbia Basin TRT: Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs. Attachment E: Population/Major Population Grouping Summaries (by ESU). (http://www.nwfsc.noaa.gov/trt/col_docs/viabilityupdatememo.pdf)

James, G. 1984. Grande Ronde River basin: recommended salmon and steelhead habitat improvement measures. Confederated Tribes of the Umatilla Indian Reservation. Pendleton, Oregon.

Jefferts, K. B., P.K. Bergman, and H.F. Fiscus. 1963. A coded wire identification system for marco-organisms. Nature (London) 198:460-462.

Johnson, G., J. Kuskie, W. Nagy, K. L. Liscom, and L. C. Stuehrenberg. 1982. The John Day Dam powerhouse adult fish collection system evaluation, 1979-1980. Report to U.S. Army Corps of Engineers, Contract DACW57-80F-0166, 102 p. Appendixes. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112 2097.)

Jonasson, B.C., J.V. Tranquilli, M.L. Keefe and R.W. Carmichael. 1997. Investigations into the early life history of naturally produced spring Chinook salmon in the Grande Ronde River basin. Annual Progress Report. Oregon Department of Fish and Wildlife. LaGrande, Oregon. Bonneville Power Administration. Project No. 92-026-04.

Jordan, C. and 15 co-authors 2002. Mainstem/Systemwide Province Stock Status Program Summary. Guidelines for Conducting Population and Environmental Status Monitoring. February 22, 2002. Prepared for the Northwest Power Planning Council. http://www.cbfwa.org/files/province/systemwide/subsum/020515StockStatus.pdf

Kaufmann, P.R., P. Levine, E.G. Robinson, C. Seeliger, and D.V. Peck. 1999. Quantifying physical habitat in wadable streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.

Karlin, S., and H.M. Taylor. 1981. A second course in stochastic processes. Academic Press, New York, New York, USA.

Keefe, M., R.W. Carmichael, B.C. Jonasson, R.T. Messmer, and T.A. Whitsel. 1994. Investigations into the life history of spring Chinook salmon in the Grande Ronde River basin. Annual Progress Report. Bonneville Power Administration, Portland, OR.

Keefer, R.B., and K Forster. 1991. Intensive evaluation and monitoring of Chinook salmon and steelhead trout production, Crooked River and upper Salmon River sites. Part II *in* Idaho Fish and Game. 1991. Idaho habitat and natural production monitoring. Annual Progress Report. Bonneville Power Administration, Portland, OR.

Keefer, R.B., P.R. Bunn, and J.Johnson. 2002. Natural production monitoring and evaluation. IDFG Report 02-24. Boise, Idaho.

Keniry, P.J. 2001-2003. Personnel communication.

Krimbas, C. B. and S. Tsakas. 1971. The genetics of *Dacus oleae*. V. Changes of esterase polymorphism in a natural population following insecticide control--selection or drift? Evolution 25:454-460.

Krueger, C.C. and Daniel J. Decker. 1993. The process of fisheries management. Pages 33-54 *in* C.C. Kohler and W.A. Hubert (ed.). Inland Fisheries Management in North America. American Fisheries Society, Bethesda, Maryland.

Kuehl, S. 1986. Hydroacustic evaluation of fish collection efficiency at Lower Granite Dam in spring 1985. Report to U.S. Army Corp of Engineers, Walla Walla, Washington.

Lande, R. and G.F. Barrowclough. 1987. Effective population size, genetic variation, and their use in population management. Pages 87-124 in M. Soule, editor. Viable Populations for Conservation. Cambridge University Press. Cambridge, England.

Leider, S.A., M.W. Chilcote, and J.J. Loch. 1984. Spawning characteristics of sympatric populations of steelhead trout *(Salmo gairdner*i): evidence for partial reproductive isolation. Can. J. Fish Aquat. Sci. 41:1454-1462.

Lewontin, R. C., and J. Krakauer. 1973. Distribution of gene frequency as a test of the theory of the selective neutrality of protein polymorphisms. Genetics 74:175-195.

Lichatowich, J.A., and S. Cramer. 1979. Parameter selection and sample sizes in studies of anadromous salmonids. Information Report Series, Fisheries number 80-1. Oregon Department of Fish and Wildlife, Portland, Oregon.

Lichatowich, J.A., and J.D. McIntyre. 1987. Use of hatcheries in the management of Pacific salmonids. American Fisheries Society Symposium 1:131-136.

Lichatowich, J.A., L.E. Mobrand, L.J. Costello, and T.S. Vogel. 1996. A history of frameworks used in management of Columbia River Chinook salmon. Pages 1 -87 *in* Mobrands Biometrics Inc. Applied Ecosystem Analysis – Background. EDT: The ecosystem diagnosis and treatment method. Contract 94/AM/33213. Bonneville Power Administration, Portland, Oregon.

Lister, D.B., D.G. Hickey, and I. Wallace. 1981. Review of the effects of enhancement strategies on the homing, straying and survival a Pacific salmonids. Department of Fisheries and Oceans, Vancouver, B.C., Canada.

Lockwood, Roger N. and D. B. Hayes. 2000. Sample Size for Biological Studies. Chapter 6 *in* Schneider, James C. (ed.) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.

LSRCP. 2002a. Hatchery and genetic management plan (HGMP) for Imnaha Basin summer Chinook . Oregon Department of Fish and Wildlife, Portland, Oregon. 71pp.

LSRCP. 2002b. Hatchery and genetic management plan (HGMP) for Grande Ronde Basin spring Chinook . Oregon Department of Fish and Wildlife, Portland, Oregon. 71pp.

LSRCP. 2002c. Lower Snake River compensation program annual operation plan (AOP). February 1, 2002 to January 31, 2003. Oregon Department of Fish and Wildlife, Portland, Oregon. 39pp.

Marmorek, D.R. and C.N. Peters (eds.). J. Anderson, R. Beamesderfer, L. Botsford, J. Collie, B. Dennis, R. Deriso, C. Ebbesmeyer, T. Fisher, R. Hinrichsen, M. Jones, O. Langness, L. LaVoy, G. Matthews, C. Paulsen, C. Petrosky, S. Saila, H. Schaller, C. Toole, C. Walters, E. Weber, P. Wilson, M.P. Zimmerman. 1998. Plan for Analyzing and Testing Hypotheses (PATH): Retrospective and Prospective Analyses of Spring/Summer Chinook Reviewed in FY 1997. Compiled and edited by ESSA Technologies Ltd., Vancouver, B.C.

Marmorek, D.R., I.J. Parnell, M. Porter, C. Pinkham, C.A.D. Alexander, C.N. Peters, J. Hubble, C.M. Paulsen and T.R. Fisher. 2004. A Multiple Watershed Approach to Assessing the Effects of Habitat Restoration Actions on Anadromous and Resident Fish Populations. Prepared for Bonneville Power Administration, Portland, Oregon. 420 pp.

Marshall, T.C., J. Kruuk and L. Pemberton. 1998. Statistical confidence for likelihood-based inference in natural populations. Molecular Ecology 7(5): 639-655.

Matthews, G.M., J.R. Harmon, S. Achord, O.W. Johnson, and L.A. Kubin. 1990. Evaluation of transportation of juvenile salmonids and the related research on the Columbia and Snake rivers, 1989. National Marine Fisheries Service, Seattle, Washington.

McElhany, P., M.H. Ruckelshaous, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionary significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.

McGregor, A.J., P.A. Milligan, and J.E. Clark. 1991. Adult mark-recapture studies of Taku River salmon stocks in 1989. Technical Fishery Report 91-05. Alaska Department of Fish and Game. Juneau, Alaska.

Milner, G. B., D. J. Teel, F. M. Utter, and C. L. Burley. 1981. Columbia River stock identification study: validation of method. Ann. Rep. Res. NOAA, Northwest and Alaska Fisheries Center, Seattle, Washington, 35

Montgomery, D.R. 1995. Input-and output-oriented approaches to implementing ecosystem management. Environmental Management Vol, 19, No. 2

Montgomery Watson. 2001. NEOH Imnaha and Grande Ronde spring Chinook step 2 submittal: preliminary design report. Project No. 88-53. Report to Bonneville Power Administration, Portland, Oregon.

Moore, K. M. S., K. K. Jones, and J. M. Dambacher. 1999. Methods for stream habitat surveys. Oregon Department of Fish and Wildlife.

Moran, P., D. A. Dightman, L. K. Park. 1998. Nonelectrophoretic genotyping using allele-specific PCR and a dsDNA-specific dye. Biotechniques 24:206-212.

Morin, P.A., Saiz, R. & Monjazeb, A. 1999. High-throughput single nucleotide polymorphism genotyping by fluorescent 5' exonuclease assay. BioTechniques 27: 538-552.

Moran, P. 2002. Current conservation genetics: building an ecological approach to the synthesis of molecular and quantitative genetic methods. Ecology of Freshwater Fish 11:30-55.

Moran, P., D. A. Dightman, R. S. Waples, and L. K. Park. 1997. PCR-RFLP analysis reveals substantial population-level variation in the introns of Pacific salmon (*Oncorhynchus* spp.). Mol. Mar. Biol. Biotechnol. 6:318-330.

Moran, P. and J. Baker. 2002. Inhibitory compounds reduce PCR efficiency in genotyping archived fish scales. Transactions of the American Fisheries Society 131: 109–119.

Moring, J.R. 1993. Anadromous stocks. Pages 553-580 *in* C.C. Kohler and W.A. Hubert (ed.). Inland Fisheries Management in North America. American Fisheries Society, Bethesda, Maryland.

Mundy, P.R.. 1999. Status and expected time to extinction for Snake River spring and summer Chinook stocks: the doomsday clock and salmon recovery index models applied to the Snake River Basin. Tout Unlimited, Portland, Oregon. 29p.

Mundy, P.R. and K.L. Witty. 1998. Draft Imnaha Fisheries management plan. Document for managing production and broodstock of salmon and steelhead. S.P. Cramer and Associates. Gresham, Oregon.

Myakishev, M.V., Khripin, Y., Hu, S. & Hamer, D.H. 2001. High-throughput SNP genotyping by allele-specific PCR with universal energy-transfer-labeled primers. Genome Research 11: 163-169.

National Research Council. 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington D.C.

Neeley, D. K., K.L. Witty and S.P. Cramer. 1993. Genetic risk assessment of the Imnaha master plan. Prepared for the Nez Perce Tribe. S.P. Cramer and Associates, Gresham, Oregon.

Neeley, D. K., K.L. Witty and S.P. Cramer. 1994. Genetic risk assessment of the Grande Ronde master plan. Prepared for the Nez Perce Tribe. S.P. Cramer and Associates, Gresham, Oregon.

Neff, B.D., P. Fu, and M.R. Gross. 2000. Microsatellite multiplexing in fish. Transactions of the American Fisheries Society 129:584-593.

Nei, M. and F. Tajima. 1981. Genetic drift and estimation of effective population size. Genetics 98:625-640.

Neter, J., W. Wasserman, and M.H. Kutner. 1989. Applied linear regression models: second edition. Irwin. Homewood. 667 pp.

Nez Perce Tribe. 2001. Tribal resource management plan for the Imnaha River subbasin. Department of Natural Resources Management, Lapwai, Idaho.

Nicolas, J.W. and L.A. VanDyke. 1982. Straying of adult coho salmon to and from a private hatchery at Yaquina Bay, Oregon. Oregon Department of Fish and Wildlife, Fish Division Report, Portland, Oregon.

Nielsen, L.A. 1992. Methods of marking fish and shellfish. American Fisheries Society, Special Publication 23.

NMFS. 1992. Endangered and threatened species; threatened status for Snake River spring/summer Chinook salmon, threatened status for Snake River fall Chinook salmon. Federal Register [Docket No. 910647-2043, 22 April 1992] 57 (78): 14,653 – 14,662.

NMFS. 2000. Biological Opinion: Operation of the federal Columbia River power system including the juvenile fish transportation program and the Bureau of Reclamation's 31 projects, including the entire Columbia Basin Project. July 27, 2000.

NOAA Fisheries. 2003. Draft research, monitoring and evaluation plan for the NOAA-Fisheries 2000 federal Columbia River power system biological opinion. FCRPS BiOp RME Plan, Portland, Oregon.

Norusis, M.J. 1999. SPSS 9.0 Guide to data analysis. Prentice Hall, Upper Saddle River, New Jersey.

Nowak, M.C. and 25 co-authoring agencies. 2001. Draft Grande Ronde Subbasin summary. Prepared for the Northwest Power Planning Council. 256 pp.

NPPC (Northwest Power Planning Council). 1994. Columbia River Basin Fish and Wildlife Program. Portland, OR.

NPPC (Northwest Power Planning Council) 1999. Multi-species framework – conceptual foundation of the framework process. Northwest Power Planning Council, Portland, Oregon.

Oatman, J.B. 2003. Personal communication.

ODFW. 1990. Evaluation of the Lower Snake River Compensation Plan facilities, 1986 – 1989. Oregon Department of Fish and Wildlife, Portland, Oregon.

Olsen, J. B., J.K. Wenberg, and P. Bentzen. 1996. Semiautomated multilocus genotyping of Pacific salmon (*Oncorhynchus* spp.) using microsatellites. Mol. Mar. Biol. Biotechnol. 5:259-272.

Olsen, E.M. and L. A. Vollestad. 2001. An evaluation of visible implant elastomer for marking age 0 brown trout. North American Journal of Fisheries Management 21:967-970.

Park, L. K., and P. Moran. 1994. Developments in molecular genetic techniques in fisheries. Reviews in Fish and Fisheries Biology 4:272 299.

Park, L. K., P. Moran, and D. Nickerson. 1994. Application of the oligonucleotide ligation assay (OLA) to the study of Chinook salmon populations from the Snake River. In, L. K. Park, P. Moran and R. S. Waples (eds.). Application of DNA technology to the management of Pacific salmon. U.S. Dep. Commer., NOAA Tech. Memo NMFS NWFSC-17:91-97.

Park, L. K., P. Moran, and D. Dightman. 1995. A polymorphism in intron D of the Chinook salmon growth hormone 2 gene. Animal Genetics. 2(26):285.

Paulsen, C.M. and R.A. Hinrichsen. 2002. Experimental management for Snake River spring-summer Chinook (Oncorhynchus tshawytsch): trade-offs between conservation and learning for a threatened species. Canadian Journal of Fisheries and Aquatic Science. Volume 59: 717-725.

Peterman, R.M., 1990. Statistical power analysis can improve fisheries research and management. Canadian Journal of Fisheries and Aquatic Sciences 47:2-15.

Rajwani, K.N. and C. J. Schwarz. 1997. Adjusting for missing tags in salmon escapement surveys. Canadian Journal of Fisheries and Aquatic Sciences 54: 800-808.

Raymond, M. and F. Rousset. 1995. An exact test for population differentiation. Evolution 49:1280-1283.

RASP (Regional Assessment of Supplementation Programs). 1992. Supplementation in the Columbia River Basin, Parts 1 through 5. Report to the U.S. Department of Energy, Bonneville Power Administration.

Reisenbichler, R.R.. 1988. Relation between distance transferred from natal stream and recovery rate for hatchery coho salmon. North American Journal of Fisheries Management 8: 172-174.

Ricciardi, L.M. 1977. Diffusion processes and related topics in biology. Lecture Notes in Biomathematics 14.

Ryman, L. and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Conservation Biology. 5(3): 325-329.

Schaefer, MB 1951. A study of the spawning populations of sockeye salmon in the Harrison River System, with special reference to the problem of enumeration by marked members. Int. PAC. Salmon fish. Bull. 4: 207p.

Schlosser, I.J. and P.L. Angermeier. 1995. Spatial variation in demographic processes of lotic fishes: conceptual models, empirical evidence, and implications for conservation. American Fisheries Society Symposium 17.

Seber, G.A.F. 1982. The estimation of animal abundance and related parameters, second edition. Griffin, London.

Sharma, R. 2003. Personal communication.

Slaney, P. A., L. Berg and A.F. Tauz. 1993. Returns of hatchery steelhead relative to site of release below an upper-river hatchery. North American Journal of Fisheries Management 13: 558-566.

Smith, B. 2003. Personal communication.

Smith, S.G., J.R. Skalski, J.W. Schlechte, A. Hoffmann and V.Cassen. 1994. SURPH.1 Manual. Statistical survival analysis of fish and wildlife tagging studies. Report to Bonneville Power Administration. Contract DE-B179-90BP02341, Project 89-107. 268 p.

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and procedures of statistics: a biometrical approach, 3rd edition. McGraw-Hill, New York.

Steward, C.R. 1996. Monitoring and evaluation plan for the Nez Perce Tribal Hatchery. Contract report to Bonneville Power Administration, Portland, Oregon, BPA Report DOE/BP-36809-2.

Swan, G. A., R. F. Krcma, and F. J. Ossiander. 1986. Continuing studies to improve and evaluate juvenile salmonid collection at Lower Granite Dam, 1985. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H-0034, 37 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Thom, B. A., K. K. Jones, P. S. Kavanagh, K. E. M. Reis. 2000. 1999 Stream Habitat Conditions in Western Oregon. Monitoring Program Report Number OPSW-ODFW-2000-5, Oregon Department of Fish and Wildlife, Portland, Oregon.

Thomas, L. and F. Juanes. 1996. The importance of statistical power analysis: an example from *Animal Behavior*. Animal Behavior, 52: 856-859.

Thompson, R.N., J.B. Haas, L.M. Woodall, and E.K. Holmberg. 1958. Results of a tagging program to enumerate the numbers and to determine the seasonal occurrence of anadromouis fish in the Snake River and its tributaries. Fish Commission, Oregon. 202 pp.

Thompson, R.N. and J.B. Haas. 1960. Environmental survey report pertaining to salmon and steelhead in certain rivers of eastern Oregon and the Willamette River and its tributaries. Part I. Survey of eastern Oregon Rivers. Fish Commission of Oregon, Research Division, Clackamas, OR.

U.S. Army Corps of Engineers (USACE). 1975 Lower Snake River fish and wildlife compensation plan. USACE Special Report, Walla Walla, Washington.

Utter, F., P. Aebersold, and G. Winans. 1987. Interpreting genetic variation detected by electrophoresis. In N. Ryman and F. Utter (editors). Population Genetics and Fishery Management, p. 21-45. University of Washington Press, Seattle.

Vincent, E.R. 1987. Effects of stocking catchable-size hatchery rainbow trout on two wild trout species in the Madison River and O'Dell Creek, Montana. North American Journal of Fisheries Management 7:91-105.

Wallowa County and Nez Perce Tribe. 1993. Wallowa County and Nez Perce Tribe Salmon Recovery Plan. Nez Perce Tribe, Lapwai, Idaho.

Waples, R. S. 1988. Estimation of allele frequencies at isoloci. Genetics 118:371-384.

Waples, R. S. 1989. A generalized method for estimating effective population size from temporal changes in allele frequency. Genetics 121:379-391.

Waples, R. S. 1990. Conservation genetics of Pacific salmon. III. Estimating effective population size. J. Heredity 81:277-289.

Waples, R.S. 1991. Pacific salmon, *Oncorhynchus* spp., and the definition of "species" under the endangered species act. Marine Fisheries Review 53(3):11-22

Waples, R. S., and P. E. Smouse. 1990. Evaluation of gametic disequilibrium analysis as a means of identifying mixtures of salmon populations. American Fisheries Society Symposium 7:439-458.

Waples, R.S., O.W. Johnson, P.B. Abersold, C.K. Shflett, D.M. VanDoornik, D.J. Teel, and A.E. Cook. 1993. A genetic monitoring and evaluation program for supplemented populations of salmon and steelhead in the Snake River basin. (Contract No DE-A179-89BP00911), Project Number 89-096, Bonneville Power Administration, Portland, Oregon.

Wilson, W.H., J.R. Ruzycki, R.W. Carmichael, S. Onjukka, G. Claire, and J. Seals. 2001. John Day Basin spring Chinook salmon escapement and productivity monitoring. Annual report to Bonneville Power Administration, Contract No. 98I11646, Portland, Oregon.

Witty, K.L. 1998. Annual Report, Wallowa Fish District, ODFW, Enterprise, Oregon.

Zar, J.H. 1984. Biostatistical analysis, 2nd edition. Prentice-Hall, Englewood Cliffs, New Jersey.

Zimmerman, Brian, B. Ashe, and S. Patterson. 2002. Grande Ronde Spring Chinook Hatchery Management Plan. Northeast Oregon. 9pp.

Appendix A

NEOH Management Questions (Alphanumeric reference linked Management Objectives and assumptions in main document)

1. What is the current status and trend of the natural populations of Chinook salmon in the Imnaha and Grande Ronde subbasins? (1A, 1B, 1C, 2A, and 7)

2. Are hatchery strategies effectively meeting program goals?
    a. Are there more naturally produced fish in target streams as a result of the hatchery program? (1)
        i. What is the reproductive success of hatchery fish relative to the reproductive success of natural fish? (1A, 1B, 1D)
        ii. Does fish health vary among naturally produced and hatchery reared components of the populations and if so what are the effects? (6?)
        iii. Do current habitat conditions limit natural production or hatchery program performance? (1E, 7B)
        iv. To what extent will juvenile release methods and strategies (size, time, location) affect supplementation success (long-term sustainability)? (6)
        v. To what extent will rearing and acclimation of Chinook salmon in Imnaha and Grande Ronde water enhance smolt-to-adult survival and return fidelity? (6)
        vi. Do the releases of hatchery-reared spring-summer Chinook salmon achieve the desired level of adult returns? (5A)
        vii. How can hatchery strategies be improved to increase natural production? (6A)
    b. Do natural and hatchery reared components within a treatment stream continue to comprise a single population regarding life history and genetic profiles?
        i. Is genetic or life history divergence occurring between natural and hatchery components? (2A, 2B, 2C)
        ii. Are changes in life history and genetic characteristics occurring within the combined population? (2A, 2B, 2C)
    c. Does the NEOH program alter inter and intra-species specific abundance and behavior? (1D, 1C)
    d. Is there a difference in performance or impacts between program components (production strategies and treatments) and if so why? (6A)
    e. Can management actions (harvest, weirs, adult out-plants, and production strategies) be effectively used to implement spring Chinook salmon management agreements in northeast Oregon?
        i. How will supplementation influence near and short term production of the target and non-target populations? (1D)
        ii. Can adult Chinook salmon returns to the Imnaha and Grande Ronde subbasins be accurately predicted? (5B)
    f. Can hatchery strategies support harvest and supplementation consistently? (5A)

Specific Genetic Monitoring Questions from Proposal 199806000

1. What is the relative fitness of hatchery fish when they spawn in the wild? –Tested explicitly in Objective 6 through parentage analysis. Tested indirectly via allele frequency monitoring in tier 2 sites where the hatchery population is distinct from the wild (e.g., Dworshak B-run steelhead).
2. To what extent does hatchery production undermine local adaptation in a manner that threatens the long-term viability of salmonids? –Our study design provides the best opportunity available with current technology to evaluate changes in local adaptation and stock-specific, indeed family-specific, reproductive success.
3. Can we quantify the ecological consequences of hatchery production (and proposed improvements in hatchery practices) in terms of altered survival of wild fish? –This study will provide insight into, for example, density dependent performance differences in hatchery and wild fish. In 1999, very few adult steelhead fish returned to Little Sheep Creek. In that year, we saw hatchery fish do markedly better than in 2000 when 2.5 times more fish were passed over the weir, and the ratio of hatchery to wild fish was 2.4:1 rather than 15:1.
4. Do hatchery reform measures work in the sense of yielding adequate smolt-to-adult returns of hatchery fish to support harvest and rebuild wild stocks? –Again, our study offers real-time evaluation of changes in reproductive success that might result from improved hatchery practices.
5. Can invasive husbandry technologies such as captive broodstocks be used to retain population uniqueness and aid in recovery of stocks on the verge of extinction? –The proposed expansion of M&E for Chinook in the Lostine River and Catherine Creek will reveal both potential changes in the genetic characteristics of these two captive brood stocks, as well as providing stock-specific descriptions of reproductive performance.

Thus, all five of the central questions posed in the CBFWA planning process related to artificial propagation are addressed directly in our study. In many cases our methods may be the only practical way of obtaining such answers, especially on short time scales. This genetic monitoring study is therefore an essential component of a more comprehensive, cross-disciplinary monitoring and evaluation program for salmon supplementation and, in the case of Lostine River and Catherine Creek, captive broodstock propagation.

Appendix B

Grande Ronde Basin Spring Chinook Hatchery Management Plan

September 2002

The Grande Ronde Basin spring Chinook hatchery program consists of two integral parts; the Lower Snake River Compensation Plan (LSRCP) mitigation program and the Bonneville Power Administration (BPA) captive broodstock program. The LSRCP has a specific spring/summer Chinook goal to return 58,700 adults into the Snake River of which 5,820 adults comprise the Grande Ronde component of the overall goal. To meet the LSRCP Grande Ronde adult goal, a juvenile production target of 900,000 fish at 15 to 20 fish per pound has been identified. The BPA program was established with the intent of maintaining a minimum critical threshold population of 150 adult spawners per tributary for the upper Grande Ronde River, Catherine Creek, and Lostine River. The Tribes and ODFW have identified other adult return goals in various documents. A major objective of this plan is to integrate these two artificial production components into a coordinated restoration effort.

Grande Ronde Basin co-managers have agreed to a diversified approach for managing the spring Chinook hatchery programs in the upper Grande Ronde River, Catherine Creek, and Lostine River. This plan outlines strategies for the upper Grande Ronde River, Catherine Creek, and Lostine River subbasins that incorporate various levels of hatchery intervention and genetic risk management. In addition, the plan outlines a strategy for the reintroduction of spring Chinook into Lookingglass Creek. The co-managers will develop additional management details specific to Lookingglass Creek that are consistent with this document. These details will be incorporated into section 10 and 7 permits and HGMPs for Lookingglass similar to existing documents for upper Grande Ronde, Catherine Creek, and Lostine River.

This plan is broken out into two time frame components; a near term period while the captive broodstock performance evaluation is being conducted and a long term period after the evaluation has been completed. A full review and assessment of the plan will occur in 2005. A more thorough narrative of the specific subbasin details follows along with a discussion of the production logistics assumptions made for Lookingglass Hatchery.

Upper Grande Ronde River

* The adult sliding scale outlined in NMFS permits #1011, Modification 2 and #1149 will not be used for management in the upper Grande Ronde River. There is no restriction on the % of hatchery adults (conventional + captive) escaping above the weir.

* Broodstock collection guidelines will be as follows:
    - -Up to 50% of the wild fish returning to the weir can be collected.
    - -Conventional progeny hatchery fish will be collected at a rate necessary to meet the remainder of the broodstock goal (could be up to 100% of returning conventional adults).
    - -No captive progeny adults (F-1) will be used for brood.

* A juvenile sliding scale will not be used to determine smolt production limits.

* Implement an overall production goal (captive + conventional) of 250,000 smolts without any specific cap for each type of production but with a priority for conventional.

* A target of 130,000 conventional smolts will be produced in the near term (while the captive evaluation is ongoing), increasing to 250,000 in the long term.

* During the initial phase of the restoration program, the goal is to release 120,000 captive brood smolts and 130,000 conventional brood smolts to meet the research study design. However, if production of either the proposed captive or conventional smolt groups is limited or unavailable, additional smolts could be released, if available, from the other broodstock group, up to the overall production goal of 250,000.

* Additional production above the captive smolt goal will be outplanted as eggs or presmolts into Sheep Creek, Meadow Creek, and/or upper Grande Ronde River below the primary production area.

* No outplanting of progeny of another program stock will occur into this tributary.

Lostine River

* The adult sliding scale outlined in NMFS permit #1149 will be used to provide guidance for broodstock collection and escapement criteria at the weir.

* Priority for hatchery adults released above the weir will be for conventional adults.

* Excess hatchery adults arriving at the weir based on adult sliding scale restrictions will be outplanted into Bear Creek, upper Wallowa River (above Prairie Creek), and/or Hurricane Creek.

* No captive brood progeny (F-1) will be taken for hatchery broodstock.

* A juvenile sliding scale will not be used to determine smolt production limits.

* Implement an overall production goal (captive + conventional) of 250,000 smolts with a specific cap of 150,000 for captive brood production and with a priority for conventional. The cap may be exceeded under emergency conditions if agreed to by all co-managers.

* A target of 130,000 conventional smolts will be produced in the near term (while the captive evaluation is ongoing), increasing to 250,000 in the long term.

* During the initial phase of the restoration program, the goal is to release 120,000 captive brood smolts and 130,000 conventional brood smolts to meet the research study design. If production of the proposed captive brood smolt group is limited, additional smolts could be released from the conventional broodstock group up to the overall production goal. However, if production of the proposed conventional smolt group is limited or unavailable, only up to an additional 30,000 captive brood smolts could be released if the cap is in place.

* Additional production above the captive smolt cap will be outplanted as eggs or presmolts into Bear Creek, upper Wallowa River (above Prairie Creek), Hurricane Creek, and/or upper Lostine River (if no research conflicts).

* No outplanting of progeny of another program stock will occur into this tributary.

Catherine Creek

* The adult sliding scale outlined in NMFS permits #1011, Modification 2 and #1149 will be used to provide guidance for broodstock collection and escapement criteria at the weir.

* Priority for hatchery adults released above the weir will be for conventional adults.

* Excess hatchery adults arriving at the weir based on adult sliding scale restrictions can be outplanted into Lookingglass Creek for natural production and/or harvest augmentation or used as broodstock for Lookingglass Creek conventional production.

* No captive brood progeny (F-1) will be taken at the weir for hatchery broodstock.

* The juvenile sliding scale outlined in NMFS permits #1011, Modification 2 and #1149 will be used to determine captive brood smolt production limits. However, during the evaluation period 120,000 captive brood smolts will be released into Catherine Creek.

* In the near term period, implement an overall production goal (captive + conventional) of 250,000 smolts with a specific target for captive brood production based on evaluation needs.

* A target of 130,000 conventional smolts will be produced in the near term (while the captive evaluation is ongoing), increasing to 150,000 in the long term.

* During the initial phase of the restoration program, the goal is to release 120,000 captive brood smolts and 130,000 conventional brood smolts to meet the research study design. However, if production of the proposed captive brood smolt group is limited, additional smolts could be released from the conventional broodstock group up to the overall production goal.

* After the captive brood evaluation is completed, the overall production goal would be reduced to 150,000 smolts with a specific cap for captive brood production based on the juvenile sliding scale.

* Additional production above the captive brood smolt goals for both Catherine Creek and Lookingglass Creek will be outplanted as eggs or presmolts into Lookingglass Creek or Indian Creek.

* No outplanting of progeny of another program stock will occur into this tributary. Once Catherine Creek stock has been established into Lookingglass Creek, these fish could be utilized, if needed, in Catherine Creek for restoration purposes.

Lookingglass Creek

* No adult sliding scale will be used for management in Lookingglass Creek. There is no restriction on the % of hatchery adults escaping above the weir. The first potential return of unmarked adults from Catherine Creek stock releases in Lookingglass Creek will be in 2008. Until then, only marked fish of known Catherine Creek origin will be released above the Lookingglass Hatchery intake weir.

* Unmarked adults determined to be of Rapid River origin (unmarked fish returning prior to 2008) will be removed from Lookingglass Creek and distributed for subsistence.

* Any adults (conventional or captive) from known Catherine Creek stock releases can be used for broodstock to develop a conventional Lookingglass Creek stock. In the future, it is intended that unmarked fish of Catherine Creek stock (unmarked fish returning in 2008 and after) will be incorporated into the broodstock for the Lookingglass Creek conventional program.

* A juvenile sliding scale will not be used to determine smolt production limits.

* In the near term period, implement a production level cap of 150,000 smolts from Catherine Creek stock.

* After the captive brood evaluation is completed, the production goal will increase to 250,000 smolts in conjunction with lowering the Catherine Creek production goal to 150,000 smolts.

* If smolt production space is limited by the other three tributary's production then a presmolt program of up to 250,000 will be implemented in conjunction with or in place of smolt production. If smolt production is at full capacity, no presmolts will be released. Total releases within a brood year will be limited to 250,000 fish.

- Lookingglass Hatchery Details

* During the periods while the captive brood performance evaluation is ongoing and prior to NEOH being implemented, space limitations will affect the goals outlined in the management tables. The following criteria have been outlined for production at Lookingglass Hatchery:

  - There are 12 raceways available for Grande Ronde tributary production. Allocation of raceway space will be made in the AOP process based on the prioritization sequence outlined below. If additional raceway space becomes available the extra space will be allocated in the same manner as other raceway space at the facility using the same prioritization sequence.
    1) 2 raceways each for captive broodstock evaluation production for Lostine, Catherine Ck, and upper Grande Ronde (6 total).
    2) 2 raceways each for conventional production for Lostine, Catherine Ck, and upper Grande Ronde (6 total).

3) 2 raceways for Lookingglass Creek production (as available).
4) Non-evaluation (i.e. production) captive brood for Lostine, Catherine Ck, and upper Grande Ronde. Within this group, priority for space will be allocated based on which tributary(s) has the least production available from the evaluation and conventional groups (as available).
5) Segregated BKD groups above 0.8 ELISA reading (as available).

- The captive brood evaluation groups for Lostine, Catherine Ck, and upper Grande Ronde will be loaded at a target of 60,000 smolts per raceway.

- Lostine, Catherine Ck, and upper Grande Ronde conventional/non-evaluation captive production ponds will be loaded at a target of 65,000 smolts per pond.

- Lookingglass Creek production ponds will be loaded at a target of 75,000 smolts per pond.

- Conventional and non-evaluation captive brood production for Lostine, Catherine Ck, and upper Grande Ronde can be mixed (within each specific stock) after tagging to balance raceway loadings.

* Production Goals – Every attempt will be made to adhere to the production goals identified in the tables. No captive brood adults (F0) will be outplanted unless for experimental purposes. All captive brood adults will be spawned but only enough eggs will be retained in order to meet that specific year's production need. Similarly, only enough conventional brood will be collected to meet the stated goals. It is projected that eight adults (at a 1:1 male/female ratio) are required for every 10,000 smolts of production. At that rate, 104 adults (52 females) will be collected to meet the 130,000 smolt goal, 120 adults (60 females) will be collected to meet the 150,000 smolt goal, and 200 adults (100 females) will be collected to meet the 250,000 smolt goal.

* Excess Production – Excess production can occur from two sources; eggs taken over those needed to meet identified goals or lack of hatchery space for production of a specific group based on raceway prioritization. Excess eggs will be outplanted as outlined below in the "BKD Culling" section.

* BKD Culling – BKD ELISA ranges will be established as follows; <0.2, 0.2-0.39, 0.4-0.59, 0.6-0.79, and >=0.8. Additional egg outplants to meet production targets will occur from across all family groups beginning with the highest ELISA range and proceeding downward by range until the production target is met. No segregation between production groups with ELISA readings below 0.8 will occur. If space is available, groups with ELISA readings above 0.8 may be segregated and reared. If space is unavailable, eggs from adults with an ELISA value of 0.8 or higher will be culled from the program.

Other Program Details

* Production Transition – There are three points where significant transitions will occur in the production program. The first is when fixed production for the captive broodstock evaluation is concluded and the evaluation no longer determines the production priorities

for the program. This will begin with brood year 2005 production after the initial captive brood evaluation treatments have been completed. As stated in the introduction, a full review and assessment of this plan will occur in 2005. The second point is when the conventional broodstocks are built up to a level that the captive brood programs can be phased down to a safety net status or discontinued. The last point is when natural populations have been increased to a level where the focus of hatchery production can be switched from restoration to a mitigation priority. The timeline on these last two transition periods cannot be determined at this time.

* Water Treatment – During the period prior to the NEOH improvements at Lookingglass Hatchery, a maximum of 50 pair of adults will be allowed to escape above the hatchery into upper Lookingglass Creek. After the NEOH improvements are completed, the adult restriction above the hatchery will be lifted. CTUIR will operate a weir approximately 150 yards above the Lookingglass Hatchery water intake to intercept dead and/or fallback fish as well as monitor and evaluate adult releases into upper Lookingglass Creek.

* Jack Management – Jacks will be managed at the Lostine, Catherine Ck, and Grande Ronde weirs as follows;

  - Lostine River and Catherine Creek jacks will be managed according to the adult sliding scale outlined in NMFS permits #1011 - Modification 2 and #1149.

  - For upper Grande Ronde and Lookingglass Creek, jacks will be managed as follows:

    - Wild and conventional jacks will be incorporated into the broodstock at a rate of 1 for every 5 adult fish. Captive jacks may be incorporated into the Lookingglass Creek broodstock at 10% of the adult males.
    - All wild jacks not taken for brood will be released upriver.
    - The number of hatchery jacks to be released upriver (or outplanted) will not exceed, in combination with wild jacks released, a total of 1 jack for every 10 male fish. Priority for hatchery jacks released above the weir will be for conventional jacks. Surplus hatchery jacks will be provided for subsistence or charitable purposes.

* NEOH – After the NEOH production facilities (Lostine and Imnaha) are completed, the previously identified pond loadings will be reevaluated for all production groups in order to take advantage of the additional space at Lookingglass Hatchery. In addition, the LSRCP production goal of 900,000 smolts will be reevaluated in relation to the NEOH program.

* Marking – The marking schemes for the four tributary programs during the evaluation period of the agreement are outlined below. Marking strategies will be reevaluated in 2005 as part of the overall program reassessment.

  - All evaluation captive brood production will be marked with an adipose fin clip and have a coded-wire-tag implanted.

- Conventional brood production groups for Lostine River and Catherine Creek will have an adipose fin clip with a coded-wire-tag implanted in combination with an external mark (VIE) to differentiate between conventional and captive adults.

- Conventional brood production for the upper Grande Ronde River will have a coded-wire-tag implanted only and will not be fin clipped.

- All non-evaluation captive brood production will be marked with an adipose fin clip only.

- For Lookingglass Creek, a representative group (up to 60K) will be ADCWT marked for production evaluation. The remainder of the production will be marked with an adipose fin clip only.

- Harvest – Harvest augmentation has been identified as an objective of the Lookingglass Creek reintroduction effort in conjunction with natural spawning and broodstock development objectives. Harvest as an objective has also been identified for the other three tributaries but is a longer term goal.

Table 1. Evaluation Period – Through Brood Year 2004 Production

Location	Stock	Smolt Type	Number	Surplus Outplanting Locations[1/]	Purpose	Marking	Restrictions		
							JV Number	Adult Esc	Brood
UGRR	UGRR	Captive Evaluation	120,000	NA	Evaluation and Natural Production	ADCWT	No[2]	No	Yes
		Conventional	130,000 Combined	NA	Natural Production and Brood	No Ad Clip – CWT only	No	No	No
		Captive Non-evaluation		Sheep Ck Meadow Ck UGRR	Natural Production	AD only	No[3]	No	Yes
Lostine	Lostine	Captive Evaluation	120,000	NA	Evaluation and Natural Production	ADCWT	No[2]	Yes	Yes
		Conventional	130,000 Combined[4]	NA	Natural Production and Brood	ADCWT + VIE	No	Yes	No
		Captive Non-evaluation		Bear Ck Wallowa R. Hurricane Ck	Natural Production	AD only	Yes	Yes	Yes
CC	CC	Captive Evaluation	120,000	NA	Evaluation and Natural Production	ADCWT	No[2]	Yes	Yes
		Conventional	130,000 Combined	NA	Natural Production and Brood	ADCWT + VIE	No	Yes	No
		Captive Non-evaluation		LG Ck Indian Ck	Natural Production	AD only	Yes	Yes	Yes
LGC	CC	Captive Non-evaluation	150,000	NA	Broodstock Development and Natural Production for LGC	AD only + ADCWT[6]	No	Yes[5]	No

1/ Outplanting locations for excess eggs, presmolts, or hatchery adults returning to weirs
2/ No near term restriction up to the 120,000 smolt production level identified as needed for evaluation
3/ However, priority is for conventional brood source smolts
4/ Includes a maximum of 30,000 captive brood smolts (assuming cap is in place)
5/ Escapement restricted to 100 adults above hatchery until NEOH water treatment modifications completed
6/ Up to 60K of this group will be marked for production evaluation with an ADCWT

Table 2. Post Evaluation Period – Beginning With Brood Year 2005 Production

Location	Stock	Smolt Type	Number	Surplus Outplanting Locations[1/]	Purpose	Marking	Restrictions		
							JV Number	Adult Esc	Brood
UGRR	UGRR	Captive	250,000 Combined	Sheep Ck Meadow Ck UGRR	Natural Production	Differential – Captive vs Conventional	No[2]	No	Yes
		Conventional		NA	Natural Production and Brood		No	No	No
Lostine	Lostine	Captive	250,000 Combined[3]	Bear Ck Wallowa R. Hurricane Ck	Natural Production	Differential – Captive vs Conventional	Yes	Yes	Yes
		Conventional		NA	Natural Production and Brood		No	Yes	No
CC	CC	Captive	150,000 Combined	LG Ck Indian Ck	Natural Production	Differential – Captive vs Conventional	Yes	Yes	Yes
		Conventional		NA	Natural Production and Brood		No	Yes	No
LGC	CC	Captive	250,000 Combined	NA	Broodstock Development LGC Natural Production Harvest Augmentation	Differential – Captive vs Conventional	No[2]	Yes[4]	No
	LGC	Conventional		NA			No	Yes[3]	No

1/ Outplanting locations for excess eggs, presmolts, or hatchery adults returning to weirs
2/ However, priority is for conventional brood source smolts
3/ Captive brood smolt cap of 150,000 (assuming cap is in place)
4/ Escapement restricted to 100 adults above hatchery until NEOH water treatment modifications completed

Appendix C

Facility Design Components Associated with Monitoring and Evaluation

Three major aspects of hatchery facilities require design considerations to accommodate M&E activities were reviewed in the Technical Memorandum TM ME-1 (MWH 2001) and are as follows.

<u>Adult Collection Weirs</u>: Facilities that enable operations across the entire spectrum of the run are essential for providing accurate enumeration of adult escapement, hatchery-natural composition, run timing, and age class structure. NEOH step-two preliminary designs associated with this activity are hydraulic weirs in the Imnaha River near Gumboot Creek and in the Lostine River at the Wynan site. Enumeration of adult returns (both hatchery and natural origin) is one of the key indicators in the evaluation of population status and performance.

- Reconstruction of the existing weir in the Imnaha River and construction of a permanent weir in the Lostine River to accommodate operation across full run spectrum.

<u>Fish Marking</u>: Up to three types of marks will be applied to each treatment group. Fish size impacts the ability to apply each type of mark. Mass marking using fin clips and Coded Wire Tags (CWT) can be accomplished earliest. Early rearing containers must accommodate fish up to 65mm (180fpp) to minimize fish handling and allow for fin clip and CWT marking at time of transfer to final rearing containers. Due to the time span (2 to 6 weeks) required to complete marking, the preliminary Design Report (MWH 2001) accommodates fish to 100fpp to compensate for growth during the marking period. Mass marking with Visual Implant Elastomer (VIE) tags require fish to be at least 100mm (50fpp) and preferably larger. This marking approach will require marking to occur after transfer to outside rearing containers, thus creating a desire for at least one extra tank to transfer marked fish into. The preliminary designs include outside rearing raceways that can be segregated into three isolated units to accommodate variable size treatment groups based on production level and Bacterial Kidney Disease (BKD) titer levels. This design will accommodate mass marking after fish have been transferred to outside rearing raceways. Marking with Passive Integrated Transponder (PIT) tags requires fish to be at least 60mm (210fpp) and preferably larger. PIT tags are generally applied to a subset of a treatment group and do not require fish to be segregated/transferred into a new rearing container. In all cases, marking fish prior to winter low growth period is preferable.

- Early rearing space sufficient to accommodate rearing to 180 fish/lb for mass marking in all facilities.
- Remote PIT tag detector(s) at all acclimation/release facilities.

<u>Treatment Group Size and Replication</u>: To address management objectives and support adaptive changes, new facilities need to accommodate enough containers for comparative treatments, and one additional segregation container for rearing high BKD titer progeny per stock. The preferred size for an experimental unit (treatment) is 60,000 fish (final rearing) to allow for statistical analysis of smolt-to-adult return (SAR) rates.

Experimental units for life stage survival within the hatchery will vary from individual female up to individual early rearing container. The integrity of the experimental units has to be maintained from spawned female, incubation, early rearing, outside rearing and final rearing. These "smaller" experimental units will be combined within treatment/disease groups to achieve the necessary experimental unit size for adult return evaluation.

- Rearing segregation sufficient for at least two (three desired) treatment groups at the Imnaha hatchery facilities (Marks and acclimation), two treatment groups at the Lostine and Lookingglass Fish Hatchery with one additional rearing container for BKD segregation per stock.

Final rearing segregation sufficient to support mass marking (one extra raceway or sub-dividable raceways is desirable) at each facility.